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INNOVATIONS IN PHYSICS LABORATORY PRACTICE IN UNIVERSITY

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ABSTRACT

In the conditions of developing market economy, the Bulgarian higher education should be equivalent in quality and quantity to the world and especially the European one, as well as convertible; the foreign companies and institutions should recognize i.e. the Bulgarian university education. A special research about the implementation of innovations in the field of the pedagogical technologies is needed so that the pedagogical process be enriched with ideas, methods and answers, with the help of which we could talk about integration of the Bulgarian education in the European and world research programs.

For the Bulgarian higher education (engineering in particular) the technology for formulation and implementation of the testing system is an innovation. Along with the laboratory practice in the University of mining and geodesy, multiversion tests, based on many kinds of exercises, have been worked out. The purpose of these tests is to examine the skills and the knowledge of the students, related to the carried out laboratory practice. This goal is consistent with the studied material and the time needed for the examination. The tests include problems, checking up the 6 knowledge levels, according to the taxonomy of the American psychologist Benjamin Blum. Their structure varies, so that the possibility of guessing the correct answers is minimized. The problem with cheating has also been solved with the help of the multiversion didactical test and the possibility given to the student to show knowledge obtained from reading additional science literature.

During the last few years new concepts as "reform", "reforming pedagogy", "competitive education", "innovations in education", "provocations in educational process", etc. (Bishkov, 1992; Bishkov, 1995; Guirova, 1997; Kostova, 1998) have been entering the Bulgarian pedagogical press. This is based on the fact that, although fixed European standards in the system of higher education don't exist, the basic principles, goals and problems of our education should be harmonized with the European and world requirements, disregarding the national, ethnical and political differences. Especially today, in the conditions of developing market economy, the Bulgarian higher education should be equivalent in quality and quantity as well as convertible, i.e. mobile, to the world and European one.

The prolonged isolation of the Bulgarian education (and that of the former communist countries) from the world experience demands a careful study of all the western educational achievements and their successful adaptation to the Bulgarian conditions.

A special research about the implementation of innovations in the field of the educational technologies is needed, so that pedagogical process be enriched with ideas, methods and answers. On the base of these methods and answers we could talk about integration of the Bulgarian education in the world and European research programs.

For the Bulgarian education (engineering in particular), the technology for formulating and implementing of a test system is an innovation.

By a decree from 1936 tests were not used in the former Soviet Union, also affecting former European communist countries (Bulgaria, the Czech and Slovak republic, Poland, Hungary). Scientists were forced only to translate and use popular western tests, without standardizing them towards the requirements of the educational process in their own countries.

In the 70s, articles and developments of didactical tests, as well as publications of tests in some subjects, appeared in the local press, but they were intended for students in High Schools. Tests meant for the education in physics in University did not exist yet.

If we examine the specific character of the pedagogical system in the University we'll find that its structure, according to V. Bespalko (1982), may be presented in the following way:

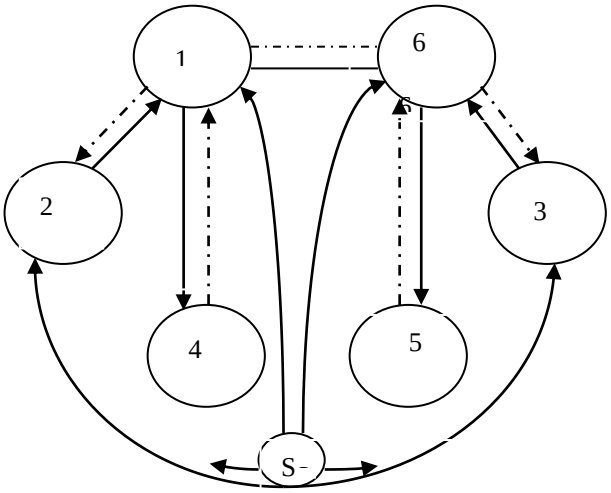
1. Goals;
2. Students;
3. Teachers;
4. Contents of the educational program;
5. Organizational units;
6. Didactical process;

Didactical tests are included in 5, like all the other elements of the pedagogical system.

If 4 is the subject Physics in a University, then 5 will include:

1. an extra cathedra method of teaching;
2. practical method (physics demonstrations and physics laboratory practice);
3. problems solving;

4. tests;
5. didactical tests;



Studying these methods, i.e. the didactical process, the problem of their effectiveness comes forward. This problem relates to the ability to follow and control the process of learning and has great importance for students and instructors. It helps students improve their learning and teachers – their teaching.

The methods that allow quantitative measuring have higher objectivity in the final result. The didactical tests in this way of thinking have standard – "with the standard we can reach the conclusion about the quality of the test carried out, i.e. the uncertainty of the different instructors about the students' mark is eliminated. The students themselves can use it as a technique for self-estimation. The more exact the students' expectation about his/her mark, the higher the quality of their work.

The result from the test has a positive effect on the students' motivation, because it does not depend on the personality of the teacher and is just a function of the students' knowledge. The opinion of the instructor about students' knowledge and skills does not matter in this case. The important thing is how many of the problems in the test have been correctly solved. This fact creates the feeling that the mark is objective and does not depend on personal opinion of a teacher, who uses "the method of estimation by sight".

Along with the laboratory practice in physics multiversion tests, based on many kinds of exercises, have been worked out. These midterm tests are a necessity in the process of education, because achieving higher results in physics needs not only objective method of estimation, but also a way "the cheating" to be avoided. To solve this big problem an average mark is advisable, one that reflects the results from the following: work with physics instruments and measuring tools, the carried out didactical tests and written protocols.

Doing tests for estimating the skills and knowledge of the students does not eliminate the possibility of using them along other methods. Achieving a better objectivity in the process of estimation and successful realizing of its basic forms need sensible combining of different methods that should be consistent with the studied material and its position in the structure of teaching.

The main advantages of didactical tests are:
1. the difficulty of the test problems can be controlled;
2. time can be saved;
3. objectivity of the mark;
4. positive motivation;

The good understanding of the potential of different tests suggests their correct usage, i.e. in the most appropriate way. Methods by PhD P. Galanov (Galanov, 1992; Galanov, 1994) have been used in formulating the midterm multiversion tests in the physics laboratory practice. The purpose of these tests is to examine the skills and the knowledge of the students during the process of their education. This goal is consistent with the studied material and the time needed for the examination. The material consists of themes that have been studied in other Universities such as Sofia University. Thus, a standardization of the physics tests and a possibility for comparing the achievements of students from different Universities is achieved.

The formulated didactical tests are in fact an effort to estimate the students' capability of doing research with the help of the studied material. Requirements for the tests (validity, exactness, simplicity and synonymity) have been met. The tests problems examine 6 knowledge levels, according to the taxonomy of the American psychologist Benjamin Blum. Their structure varies, i.e. there are problems with given answers, and the student should choose the correct one, and there are problems for finding logical mistakes; problems with diagrams that should be completed and discussed; problems for planning a result under the operation of another factor; problems checking the meaning of physical quantity; problems for checking up the understanding of the whole material; problems for examining the skills needed for finding physical quantities using an algorithm, i.e. examining the ability to use a physical law to create problems. With the help of problems like these, the possibility for guessing the right answer is minimized, and with formulating essay problems this possibility does not exist.

The system "n from 5", formulated for the needs of the extramural University of Hagen (West Germany), that has been used for examination, is a new answer for the multiple-choice problems. Tests about the studied material have been worked out. They consist of questions and problems that have 5 possible answers. The students know that they have to choose minimum 1 and maximum 3 answers. The pint of this test is to minimize the possibility of guessing the right answer, because the student has to think about all the given choices. Every right answer gets 1 point, and the highest result for a problem is 5 points, when all the choices are correct and the wrong ones are not chosen. (Bishkov, 1992).

This system is used for formulating multiple-choice problems, i.e. there are 5 answers for each problem. There is either 1 correct or 1 wrong answer, depending on what is asked in the text of the problem. The estimation is not according to the "points" method, but to the number of operations needed for the problem to be solved. Although the possibility for guessing the right answer is less than the one for problems with alternating character, it still exists (in our case with 5 given answers this possibility is 1/5, and for n problems it is 1/5*n).

The following example shows how multiple-choice problems are used in two of the choices of test N2.

N14 Electrical microscope
N15 Characteristics of a semi-conductoral diode
N16 Characteristics and parameters of a transistor
N18 Thermo electrical phenomenon

VERSION 1

Problem 10

Peltie's heat does not depend on:
a) magnitude of the electricity, passing through the solder;
b) direction of the electricity, passing through the solder;
c) resistance of the conductor;
d) magnitude of the electrical charge, passing through the solder;
e) time, needed for the electrical charge to pass through the solder.

VERSION 2

Problem 10

The sign of Peltie's heat depends on:
a) direction of the electricity, passing through the solder;
b) the sign of the emitted Jaul's heat in the conductors;
c) the sign of the Peltie's coefficient;
d) contact metal – metal;
e) contact metal – conductor.

The right answer to both of the problems is only one. The purpose is : the students should be able to tell apart and show the physical quantity that define Peltie's heat. This goal checks up the 4th knowledge level from the taxonomy of Blum.

The difficulty of the test problems is equal to the knowledge needed for solving it. For both of the versions it has been estimated theoretically, according to P.Galanov (Galanov, 1992; Galanov, 1994, Galanov, 1994).

Estimating the objective difficulty of a physics problem (that can be used for a test too) means estimating how difficult it is for the particular problem to be solved. Dividing the process of solving the problem into separate operations does this. By operation we mean every brain work that can be looked at as a specific and is done for the sake of solving the given physical problem.

Using the common instructions for solving physical problems and the algorithm for estimating their difficulty, it can be concluded that for solving problem N10 we need 12 operations. That means both of the problems are equally difficult.

The technology suggested by PhD P. Galanov (Galanov, 1992; Galanov, 1994, Galanov, 1994) allows us also to estimate a complete answer by using the number of the right operations.

The experimental defining of the difficulty of the test still has to be done. The problems need also to be tested about their quality, validity, reliability, and formulating the test versions.

Besides multiversion didactical tests certain help is offered to the students. It's called "a gun" and consists of literature, materials, protocols and reference books. (Bespalko, 1982) Creating such a situation along with the carrying out of the didactical test helps avoiding the competition between students and teachers, a normal psychological climate will be created and it will influence the education of the students, i.e. it will help bringing up character features like responsibility, independence, active behavior and so on.

Carrying out a test like this one requires the formulation of the problems to be different from the one in the textbooks, in order to avoid learning the material by heart and not understanding it.

The open book test gives the students the chance to think about the material and to test their understanding of it.

The most important skill in cases like this is to be able quickly and effectively to use the necessary information for solving problems. A criterion about the creativity of a problem exists. It's called Fuller criteria and suggests that a problem is creative if two or more physics laws should be used for its solving. For example problem N3, test N2, version N3:

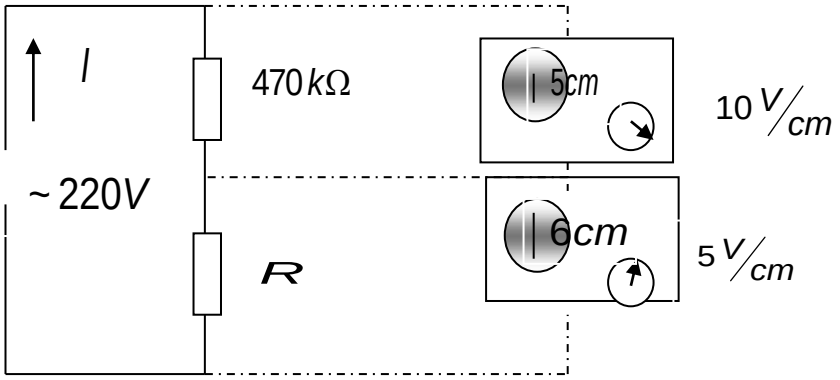
1. The resistance R, which is an unknown quantity, can be estimated with the help of an oscilloscope.

By using data from the figure, estimate and choose the right answer.
a) 282 Ω;
b) 470 Ω;
c) 32 kΩ;
d) 282 kΩ;
e) 470 kΩ.

The correct answer to this problem and choosing it (answer E) takes 29 operations to be done, which is relatively more than the number of operations needed for solving an algorithmic problem, such as problem N7, test N2, versionN1

Simple transistor amplifier with common base has coefficient of amplifying 50. What entering pressure is necessary in order to obtain outgoing signal 1 V:
a) 0,02 V

b) 0,5 V
c) 1 V
d) 50 V
e) 100 V



Solving this problem requires using one physical law and 15 operations.

Finding appropriate scale for translating percentage marks into examination marks is a serious practical and technical problem. If there are more students that have passed an exam thanks to the scale, they should be able to continue their study and this is a basic requirement for these skills.

To work successfully in many engineer fields like: electrical units, knowledge for the materials; nuclear electricity, one needs to understand the basics of contemporary physics. Physics is an important knowledge for an engineer and is "the door" towards technique and different technologies. That's why the scale for translating percentage marks into examinational ones is very strict in its requirements fir the students and has excellent prognostic validity, concerning their future knowledge

Table N1. Scale for translating percentage marks into examinational ones.

If a student gets the following percentage marks			
between	100% - 90%	gets	Excellent (6)
between	90% - 80%	gets	Very good (5)
between	80% - 70%	gets	Good (4)
between	70% - 60%	gets	Satisfactor (3)
under	60%	gets	Poor (2)

Good understanding of the possibilities given by tests as a method of examination and estimation of students' knowledge and skills will provide their thorough implementation into the process of education and objectivity of the final grade. The exam gives the student a chance to show in a systematic and thorough way his/her knowledge and demonstrate his/her skills.

In its traditional version, however, the exam (written or oral) focuses on reproduction of the studied material. Overcoming this disadvantage can be accomplished by using some versions of an exam and elimination of others as separate phases of the final estimation.

The formulated didactical midterm tests consistent with the physics practice at the University can be used as a phase of the exam. They'll provide correct information floe from students to teachers about students' progress and will make them able to examine themselves alone.

This opportunity to control your own grades and progress creates the necessity for the students to accept the tests as an objective estimation. As a result, the relationship student/teacher will be changed. The teacher will no more be just a person who demands and instructs but an assistant who helps students realize the objective requirements of the didactical test.

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