CONTINUOUS ON-LINE EVALUATION OF STUDENT SEMESTRAL ACTIVITY

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Abstract — *An attempt is made to assess activities of a student during his academic semester in a Technical University. Lectures, seminars, laboratory works, home-work are typical activities of any student. The mark received for a semestral exam serves as the criterion to judge about student's knowledge. However, this mark very often does not reflect the real state of things. In order to make the evaluation trustworthy a quantitative approach is necessary to estimate the student activity during the whole semester. The evaluation proposed is based on a continuous assessment of results achieved by each student of a group. A feature of this method is using computers to provide each student with his individual tasks for home-work and giving him a chance to check up himself. Physics is taken as a test subject but the whole approach can be generalized for any fundamental or applied engineering discipline in a Technical University.*

Index Terms — *Assessment of knowledge, Computer based examination, Home-work, Individual tasks,*

INTRODUCTION

The paper appeals to one of most important problems throughout Russia and elsewhere. This is the problem of students knowledge evaluation in the context of teaching fundamental and engineering disciplines in Technical Universities [1]-[4].

In Russian higher school the four grade system of evaluation is generally accepted: "unsatisfactory", "satisfactory", "good" and "excellent" (corresponding to marks in Russian secondary school system from "2" to "5" respectively). If a discipline is taught in a University, say, during three semesters the mark for the final examination is then transferred to the "diploma annex" which is the supplement to the diploma containing the list of major subjects dominated by a graduate with corresponding marks.

Unfortunately, there is no guarantee that this mark adequately reflects the level of knowledge in a given field of science. Taking into account that the number of students in an academic group (class) of a typical Russian University is about 25 and that the number of groups attending lectures of Professor *X* is 4-6 one can imagine that the mark given by Professor *X* to Student *Y* depends upon many aspects other than academic ones:

- Psychical state of Student *Y* and the state of his health;
- Professor's individual peculiarities and habits;
- Professor's personal attitude to Student's appearance (in case of oral exams which are very common in Russia);
- General reputation of a given academic group undergoing the exam;
- Number of days between two consequent exams (Normally there are two examination sessions in Russia - in January and in June. Each consists of 5-6 strictly scheduled exams with short intervals between them).

It is also clear that Professor *X* who has 100 -150 students attending his lectures is physically unable to know personally each of them.

The situation is better with Assistant Professors who conduct seminars and laboratory works in a particular group. They have a direct constant contact with students and know their potential and their attitude to studies. However, at exams they play but auxiliary role and are not responsible for the final mark given by the lecturer – Professor *X*.

The purpose of the present paper is to highlight a student's advance during the semester by setting the quantitative assessment of his overall activity. This assessment could be expressed as a mark in any conventional mark system accepted in Russia or elsewhere and taken into account by the lecturer when he gives his final mark for the exam.

SETTING THE QUANTITATIVE SYSTEM OF ASSESSMENT

The following kinds of student academic activity undergo the quantitative assessment:

- Lectures,
- Home-work,
- Seminars (Practicals),
- Laboratory works.

These four activities are four principal components which serve as a basis for the future consequent assessment of activity for each student of any group.

At the end of semester a mark will be set for each of these activities and finally the resultant average is to be derived. This average mark should embrace the whole semestral activity of a student and strongly influence the examination mark at his final exam.

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Let us consider separately all above mentioned kinds of student activity and ways to set the semestral mark.

Lectures

The topics of the syllabus within a semester represent separate units (or modules) of the subject lectured. They should be duly controlled by the lecturer as soon as any of these units is over.

Conservation of Momentum and Energy

1). Two little balls with masses m_1 and m_2 moving uniformly in the same direction with velocities $\boldsymbol{V_1}$ and $\boldsymbol{V_2}$ so that $V_2 > V_1$. Consider their absolutely elastic collision. The resultant heat irradiated due to collision will be equal to

A. Zero.

B. $\frac{m_1v_1^2}{2}+\frac{m_2v_2^2}{2}$.

C. $\sqrt{(m_1v_1)^2+(m_2v_2)^2}$.

D. $m_1v_1+m_2v_2$.

2). The magnitude of their resultant momentum is equal to

A. Zero

B. $m_1v_1+m_2v_2$.

C. $m_1v_1-m_2v_2$.

D. $\sqrt{(m_1v_1)^2+(m_2v_2)^2}$.

3). Consider now their inelastic collision. The resultant heat irradiated is equal to:

A. $\frac{m_1}{m_1+m_2}\cdot\left(\frac{m_1v_1^2}{2}+\frac{m_2v_2^2}{2}\right)$

B. Zero.

C. $\frac{m_1v_1^2}{2}+\frac{m_2v_2^2}{2}$.

D. $\sqrt{(m_1v_1)^2+(m_2v_2)^2}$.

4). The balls are now moving towards each other in perpendicular directions. The magnitude of their resultant momentum is equal to

A. $m_1v_1+m_2v_2$.

B. $\sqrt{(m_1v_1)^2+(m_2v_2)^2}$.

C. $m_1v_1-m_2v_2$.

D. Zero.

5). A ball falls from the height *h* onto a flat massive plate and suffers the absolutely elastic collision with its surface. What does the total energy of the balls converts into during the interaction with the plate?

A. Into heat

B. Into potential energy *mgh*.

C. Into potential energy of elastic interaction.

D. Into kinetic energy of the resultant motion

FIGURE. 1
EXAMPLE OF A LECTURE TEST

The control can be realized at the end of each unit as a written test containing theoretical questions with multiple-choice answers. If a classroom where the lectures are delivered is equipped with computer technique the whole procedure can be computerized. The questions suggested by the professor should not imply long and boring written answers. They should be easy but appeal to profound understanding by pupils of theoretical backgrounds of a law or phenomenon considered in the topic tested. A set of questions for one student should be compiled in a way that the divergence in the evaluation should be the least possible. An example of test *Conservation of Momentum and Energy* is presented on Figure 1.

The test is intended for *multiple-choise answer* system and five correct answers (*A, B, A, B, C)* make the mark 5 (excellent). Not less than 5-6 tests should be realized during the semester and the average mark calculated.

Home-work

Home-work is considered as a very important component of the whole academic process. It should always be thoroughly prepared beforehand and duly checked. The tasks of home-work should be compiled on the *individual* basis. When a home- task is the same for the whole group it often loses its value because weak students have a habit to copy the ready solutions from exercise books of strong and honest students (at least in Russia this is a common problem). Any system which allows preparing sets of *individual* tasks will give good results. It is worth suggesting one of them.

Individual Task System (ITS). The individual student work has its enormous effect only if it is being guided and controlled by professor. Home-work as a part of ITS plays an extremely important role here and it is useful only when the problems of any home-work are compiled correctly from the methodical point of view and the individual capacities and particularities of a given student are taken into account. That is the problem - not for the student but for his teacher! And the more number of students in a class the heavier is this problem. 25-30 pupils in a class is normal for an average Russian Technical University and when a home-work (consisting of 5-6 problems from a text-book) is the same for the whole class the copying from somebody's exercise-book becomes inevitable (or even very popular). Every Russian teacher is well acquainted with this sad reality which complicates his an adequate assessment of a student activity and often makes a wrong opinion about student's personality. In order to make the assessment objective and trustworthy the ITS has been elaborated. Let us consider the basic principles of the ITS.

The ITS is realized using a PC loaded with a special program designed by the author written in *C* or C^+ programming language which makes the whole system compact and allows to introduce any desirable changes in the easiest way.

A collection of problems and questions on Physics (or another subject) constitutes a subsystem of files called '*Bank Files'* which serves as a source of tasks to be issued for students. These files are always 'under construction': old problems can be removed, modified, corrected or substituted for new ones.

'Bank Files' itself is divided into several separate files containing problems on different chapters of the discipline. For Physics they are: *Mechanics, Molecular Physics, Electricity, Magnetism, Oscillations, Structure of Matter* etc. It is, therefore, a system of electronic files containing a collection of problems and questions which are used to compile tests, examination papers, home-works etc. If printed out it looks like a familiar book of problems with one exception: one of necessary numerical parameters in each problem is replaced by *S*. This *S* - parameter is a variable quantity which will be substituted for a number when a task is printed out for a student for his home-work or test. Its numerical value will be different even if the given problem is used twice in a class, i.e. for two students of the same group. Consequently, these two problems will have different answers. Figure 2 presents a fragment of the sub-file '*Mechanics*'. Five lines are reserved for each problem or question. The first line is never printed out and reserved for internal use by professor. It contains the number of a problem in the file, level of complexity, branch of the topic (kinematics, dynamics etc.) and another information.

#34-------*Conservation of Energy*—CmplxLevel: 3---
A sand bag of mass 10 *kg* is suspended with a 3 *m* long weightless string. A bullet of mass *S g* is fired with a speed 20 *m/s* into the bag. Calculate the energy converted to heat in the collision.
#35-------*Angular Momentum*-----CmplxLevel: 2-----
A wheel is rotating with an angular speed $\Omega = S$ *rad/s*on a shaf. A second identical wheel, initially at rest, is suddenly coupled to the same shaft What is the angular speed of the resultant system?
#36------*Dynamics of Particle*------CmplxLevel:4-----
A force $F = 50$ *N* is acted upon a particle whose

FIGURE. 2
FRAGMENT OF BANK FILE 'MECHANICS'

Two main sub-programs called TASK and ANSWER constitute the body of the ITS. Both programs are linked with the file VARIANT as shown on Figure 3.

File VARIANT consists of electronic matrices filled by professor with numbers of problems from *Bank Files*. Each row of any matrix corresponds to a student of the group and each column corresponds to a particular problem in the given task. Each matrix corresponds to a set of individual tasks on a given topic (e.g. Topic 1: *Kinematics*, Topic 2: *Dynamics* etc.). Consequently, sets of VARIANT are filled by professor gradually one by one.

When the program TASK is launched by professor, the number of set and the title of topic are entered by him. In the course of program realization reading of problem numbers and a consequent printing out of the corresponding problem takes place to compose a complete task of 5-6 problems to each student.

As it was mentioned above any problem contains one *S*-parameter to be replaced by a suitable numerical quantity. Replacing of this *S*–parameter is realized by means of a subroutine which substitutes the reasonable value of the

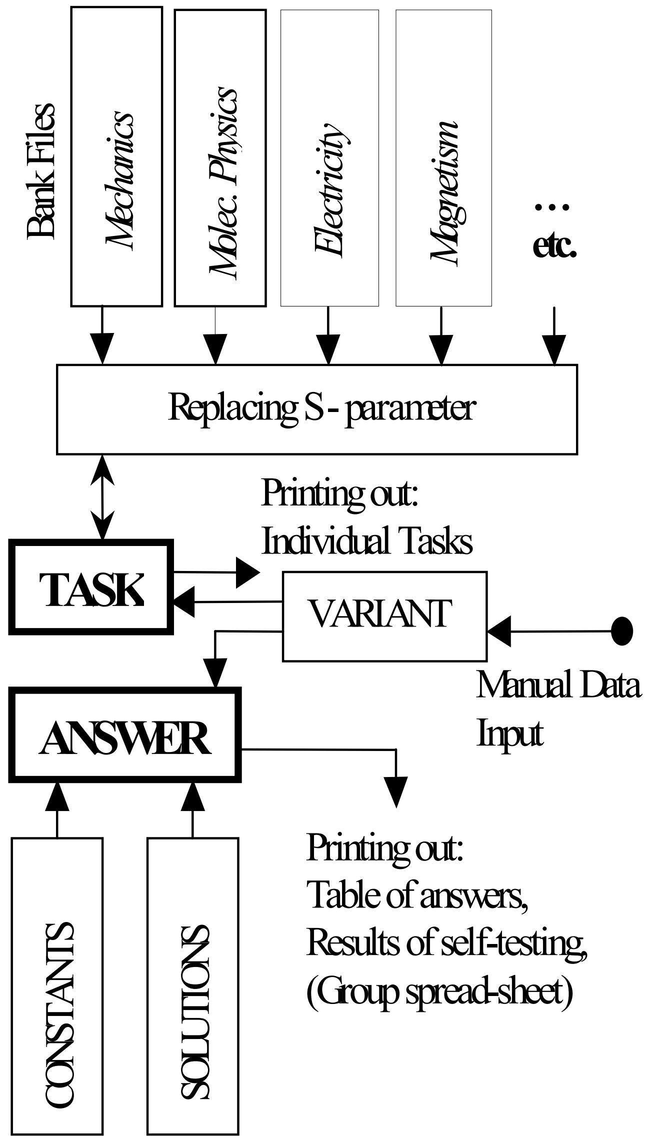

FIGURE. 3
GENERAL STRUCTURE OF THE ITS

corresponding numerical parameter. When a problem is placed several times in different places of the same set the answers will be all different.

Once printing of a given set of individual tasks is finished the program ANSWER will then be launched by professor to print *Table of Answers* to the set. ANSWER reads problem numbers and one by one calculates the numerical answers taking the general formulas from the subroutine SOLUTIONS and replacing there *S*-parameters by the numerical values.

Another function of the ANSWER is to realize *self-testing regime* which is very popular among students. This regime gives an immediate overall assessment of the whole group's activity.

The schedule for the self-testing session for a group is determined by professor. Normally, a week or two are given to let students solve the problems of the current set. Then the professor gathers students in a computer class-room where the program ANSWER is launched by him in self-testing dialogue regime. On PC's request, the *name*, *number of set*, and *number of task* are entered by each student at his PC. Then the PC requests to enter the answer of Problem 1. Once the answer is entered the PC compares it with that immediately calculated and gives out its verdict: YES or NO. The ANSWER's numerical solution in the case 'YES' may slightly differ from the result received and entered by a student. The permissible error in student's calculations is defined by the percentage (normally 5-7%) set by the professor. The options of ANSWER allow adjusting this value. As soon as the answer for the last problem is entered the session is over. The mark for the whole set is monitored on the student's display. Simultaneously, the overall spread-sheet of results (Figure 4) is being compiled on professor's display and can easily be printed out as a hard copy for his reference.

Set 3: CONSERVATION LAWS							
Task #	Name	Problems					Mark
		1	2	3	4	5	
1	Zakharov V.	Y	Y	N	Y	Y	4
2	Ivanov G.	Y	Y	Y	Y	Y	5
3	Schneider U.	N	N	N	Y	Y	2

FIGURE. 4
SPREAD-SHEET OF RESULTS

The mark not necessarily corresponds to the exact number of solved problems. There might be used other criteria which take into account the total number of problems suggested in the task, the level of complexity etc.

These spread-sheets collected by professor at a series of such sessions give him a complete picture of the state of things in the group. Namely, it enables:

- to estimate the general level of understanding of the subject (Physics, Mathematics, Civil Engineering etc.) in its practical aspect;
- to find out the most difficult for understanding topics and pay them more attention in the future;
- to let students realize themselves in their individual creative work;
- to teach students of correcting mistakes in a very productive 'Professor - Student' dialogue.

When analyzing the general results of a session the professor takes his decision to give a chance for a student to improve his results. He may easily compile (within a few minutes) a new task for U. Schneider (see Figure 4) making a particular accent on problems 1, 2 and 3 selecting carefully problems of this type for his new task.

The average mark obtained by a student for all the sessions is automatically calculated as soon as all the sessions are over. This mark is the criterion of a student's individual semestral activity at home-works.

Seminars (Practicals)

This kind of work with students gives more opportunities since it is here where a student cam demonstrate his abilities to solve the concrete problems. A seminar is normally conducted by Assistant Professor and begins with a brief excursion to theory recently delivered by the lecturer. It is necessary to underline that the seminar should never *substitute* the lecture but *support* it. Unlike traditions of the western school it is common in Russia to call a student and ask him to solve a problem (selected by professor) publicly. The author of the present paper heard many words of reproach and dissatisfaction both from students and colleagues when he experienced his teaching in Zambia and Mozambique but nobody could make him believe that this procedure was a human rights violation and normal exams (recognized by all western world) were not. It is shown by experience that it is not difficult to convince students that such a procedure is absolutely necessary. Indeed, not only professor benefits from it but student himself learns a science how to behave himself and make presentations in front of a large audience. (This is the science worth learning!)

The quantitative evaluation of activity at the seminars is made using the technique considered in details in the previous chapter. Three or four tests are compiled by the professor in the course of a semester. They are examined by the professor. Now he checks up not only answers but also the way of solving the problems. He makes his written remarks and observations in a rather 'conservative' traditional manner which can also be very useful in spite of technical progress benefits. Each set of these tests in comparison with those for home-works is more complicated. If student sessions for self-control of home-works can be compared with goods of mass consumption, the test for seminars is a 'hand-work'. As previously the average mark is derived for the whole semester.

Laboratory Works

The work in laboratories is considered by the author as very important. A laboratory is the place where all experimental and cognitive skills of a student can be realized and (what is very essential) developed.

It is needless to outline that the equipment of any student laboratory should be adequate and up-to-date. The old devices and instruments can be extremely useful for lecture demonstrations where simplicity of old instruments gives an explicit treatment of their action and lets the students penetrate into the history of science discoveries. Once a certain physical phenomenon or a law is understood by a student at lectures, some modern conventional instruments can be demonstrated by lecturer and later used at laboratory sessions [5,6]. It is the laboratory that should teach a student how to use them.

Each laboratory session normally takes place once a week and lasts 2 *academic hours* (1 academic hour = 45 min. in Russia). Eight (out of 16) sessions of a semester are intended for work performing (experimental sessions), and eight are ‘to defend’ the work (theoretical sessions). Each theoretical session follows the experimental one. Each work is carried out by a brigade of two students and they defend their work together. Two assistant professors are usually engaged into conducting of the whole session. A schedule of works should give the students the complete information (*what* and *when*). The works should be clearly described in special guide-books. The following points then undergo the evaluation:

- Readiness of a student to carry out his scheduled laboratory work;
- The experimental skills developed by student in the course of work;
- Understanding of theoretical backgrounds of the work performed.

The first point is realized at the beginning of a session as a free talk the professors have with every student of a group. The talk does not imply any deep understanding by students of a phenomenon underlying a given work. At this level the students must merely be acquainted with what they are supposed to do. Beforehand, they should have read the description of their scheduled work and know what to switch and what to turn. This is a rather friendly talk with the professor to get some hints and recommendations. A student’s work-log should be filled with some relevant notes (formulas, brief descriptions of the experimental set-up etc.). Nevertheless, students must demonstrate someunderstanding and concern. If there is none his access to the work may be cancelled or postponed.

If a student receives professor’s approval he gets the access to work and begins the experiment in accordance with the guide-book for laboratory works. At the end of the experimental session every student receives from professor a slip of paper with questions. This task is similar to those described above and compiled by professor using TASK sub-program of the ITS. The difference is that such slips do not contain numerical problems. They contain questions only – also taken from *‘Bank Files’*. These questions are about theory and about methodics of the experiment as well. The real discussion with the students during the coming theoretical session is not limited to these printed tasks. Profound understanding and good experimental skills are supposed to be demonstrated by a student to get a high mark.

The results of measurements obtained during the experimental session are signed by the professor. The later data processing is carried out by students at home and presented at the following theoretical session together with answers to the questions formulated in their printed tasks. The average mark for the overall activity in the laboratory is derived at the end of the semester.

OVERALL EVALUATION

At the end of a semester the four average marks for four principle components of student activity will be available. Together with the examination mark they are supposed to give the full and objective picture of student’s image.

These marks are extremely important and in many cases they are even more important that the marks received at the exams. Those are the functions of many random parameters of the examination day and can hardly present the real situation.

However, marks received in the course of the semester characterize a daily student work and reflect the state of things in a more adequate way. A correct quantitative evaluation of student’s day-to-day progress helps a professor to form a correct approach and a right informal attitude to every student.

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