ENHANCING EDUCATION IN SCIENCE BASED ON INFORMATION TECHNOLOGY APPLICATION

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The article regards the fundamentalization of scientific education exemplified by developing and using interactive teaching systems in physics for technical students. The system is designed for practical classes and students' individual work in a physics course according to the course syllabus. The results of the system piloting in the process of study indicate that the students' knowledge has improved.

Keywords: fundamentalization, information technology, teaching system, test items, assessment

Challenges faced by higher technical education in Russia are connected with decreasing interest in it, eliminating the examination in physics from obligatory disciplines, problems with the graduating students' employment because of weakly developing economy and crisis directly influence on the secondary school education and, as a result, students' ability to learn science and mathematics.

Maintaining and enhancing education in science and mathematics directly related to the fundamentalization of professional education (developing high professional competences of a technical university graduate) requires systematic changes in the process of teaching science and mathematical disciplines.

These changes, as well as enhancing education in science and mathematics with interrelations found between physics and mathematics, creates the basis and conditions for the fundamentalization of professional education, which enables the specialist to be quickly retrained and study new technologies and production processes at a high level of efficiency. This makes it possible to effectively develop such characteristics of a professional as a high level of professional awareness, professional adaptability and mobility, capability of self-education and self-development throughout their life, flexibility in thinking, etc. Besides, enhancing the education is impossible without introducing information technology into the educational process and resources for students' self-study [1-7]. An up-to-date model of enhancing education in science and mathematics is presented in Fig.1

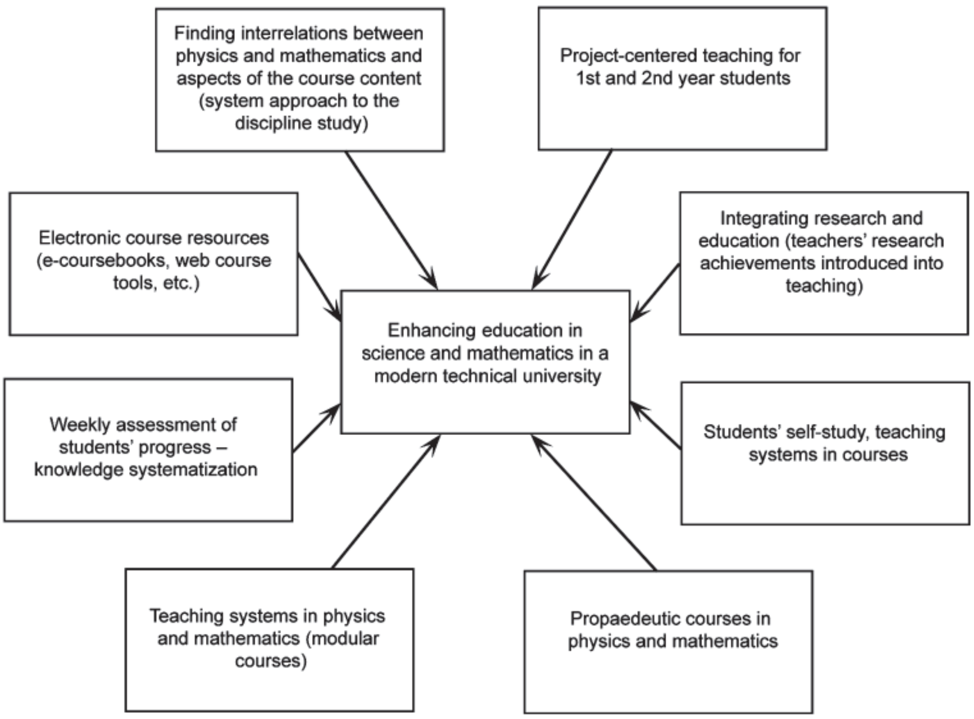

Fig. 1. Components of the enhancement of scientific education

Methods

The fundamentalization of education in science is impossible unless the interrelations between physics, mathematics and special disciplines, as well as within the course of physics, are taken into account [8]. Models in physics undergo transformation and transfer from one section of the course to another. If the system of interrelations between models within the course of physics is not presented to the student, it is almost impossible to find them without the teacher's help. The analysis of interrelations within the course of physics as well as awareness that postulates of the Special Theory of Relativity change for those of classical physics if the object velocity is much lower than that of light in the vacuum allows for applying the theoretical and deductive method rather than historic and inductive one (Fig. 2). The use of IT also makes it possible to apply the productive method (problem solving), personality-centered approach (various learning trajectories), and developmental teaching methods.

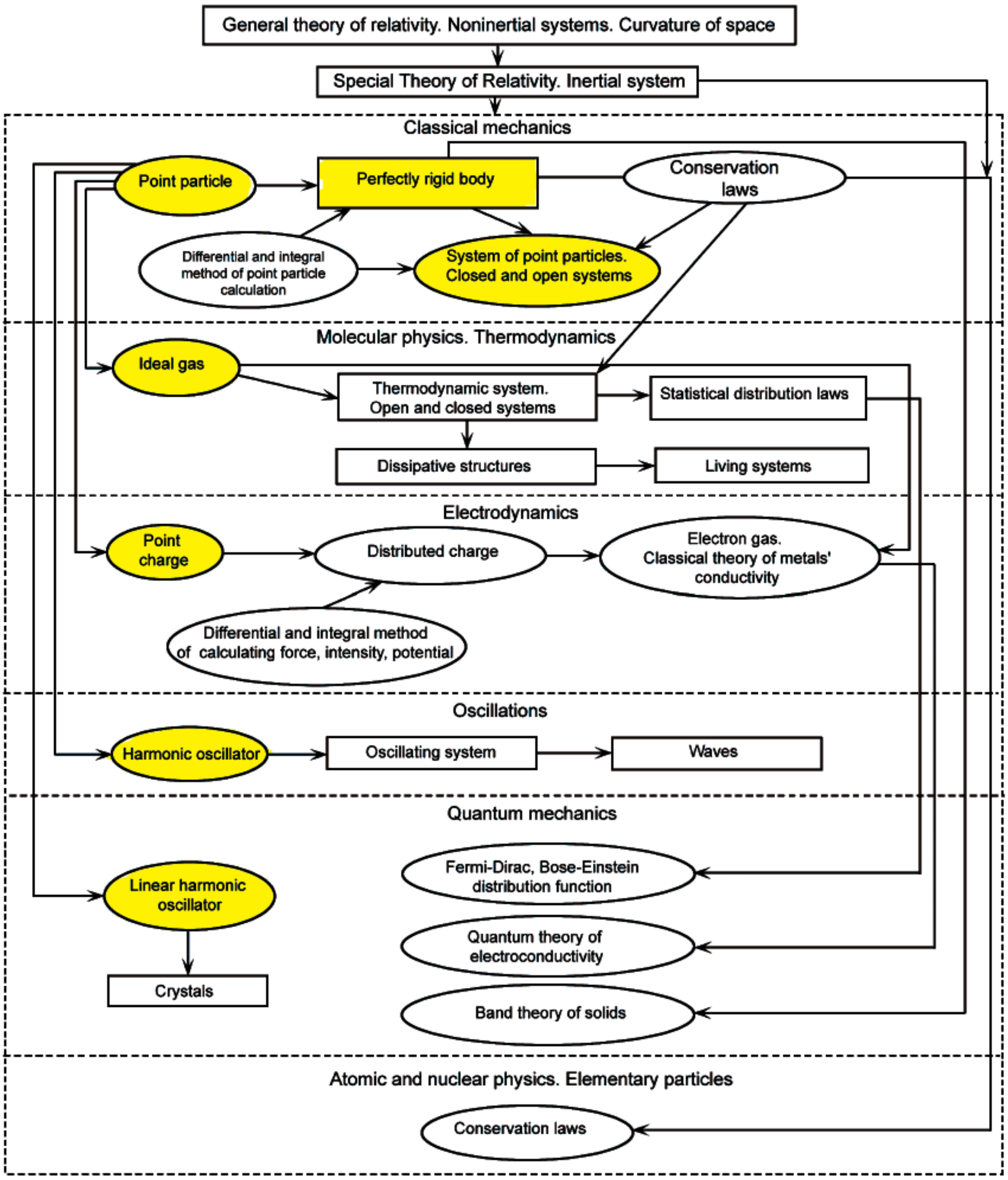

Fig. 2. Analysis of interrelations within the course of physics (system approach to the discipline study)

For the purpose of enhancing the educational process in the course of physics and fundamentalization of scientific education, an interactive physics courseware based on Macintosh and IBM PC computers has been developed in National Research Tomsk Polytechnic University. The courseware is designed for practical lessons, independent, individual students' work and distance teaching and learning. Nowadays there are four parts of the courseware which has been completely developed, tested and introduced in the teaching process. These parts are devoted to the following units: «Mechanics. Molecular Physics. Thermodynamics». (part I), «Electricity. Electromagnetism». (part II), «Oscillations. Wave Optics». (part III), «Nuclear Physics. Quantum Physics Accidence». (part IV). The courseware has been tested at lessons with full-time and part-time students of different faculties for 10 years (more than 10 thousand class hours).

Course sections:

1. Point Particle Kinematics.
2. Kinematics of Rigid Body.
3. Dynamics of Rigid Bodies.
4. Conservation Laws.
5. Special Theory of Relativity.
6. Ideal Gas Laws.
7. The First Law of Thermodynamics. Thermal Capacity. Entropy. Thermal Engines.
8. Coulomb's Law. Electric-field Intensity. Gauss Theorem.
9. Movement of Charge in the Electric Field. Potential. Intensity and Potential Relation. Electric Capacity.
10. Direct Current Laws.
11. Electromagnetism. Ampere Force. Lorentz Force. Motion of Charged Particles.
12. Biot-Savart-Laplace Law and its Application to the Calculation of Magnetic Induction and Intensity of Magnetic Fields. Material Magnetism.
13. Hall Effect. Electromagnetic Induction Law. Maxwell Equations.
14. Mechanical Oscillations and Waves.
15. Electromagnetic Oscillations and Waves.
16. Geometric Optics.
17. Interference.
18. Diffraction.
19. Polarization.
20. Thermal Emission.
21. Photoeffect. Compton Effect.
22. Hydrogen Atom according to Bohr. Linear Spectrum.
23. Quantum Physics Accidence. Particles' Wave Properties.
24. Schrödinger Equation. Particle in the Potential Well.
25. Physics of Atomic Nucleus and Particles.

Methodological support of the system [9]:

1. Theoretical section structured to be the necessary minimum and consisting of:

a) interrelations of physical values and laws with those studied at previous classes and interdisciplinary relations with other courses within the curriculum;

b) up-to-date achievements in the relevant field of science.

2. Feedback or communication to organize a dialogue between the student and the computer.

3. Non-standard test items of various types to measure students' type I and II knowledge – productive activity.

4. Solved problems (typical ones, to develop the ability to build problem solving algorithms and remember the relations in theory and a corresponding individual version of the problem to be solved independently).

5. Solved integrated problems (non-standard, original ones) to develop the ability to think creatively.

6. Progress check tasks with a wide range of skills development, including type III and VI knowledge (writing tasks relevant to the course section) – productive activity.

7. A variety of studying trajectories corresponding to the student's present proficiency level, intentions and opportunities.

8. Rating scale to assess the students' learning results at any stage of the class.

9. Facilities for modeling and simulating phenomena studied and performing simple experiments as well as video presentations.

10. Historic background (interesting didactic stories about scientists and their discoveries) and supporting illustrative material.

11. Reference material – a table of derivative values, integrals, trigonometric functions, constants, etc.

12. Comfortable conditions for studying and communication with the student.

13. Necessary conditions for self-study and individual work.

The random number generator for the dispersion of the problems' numerical data or test items provides for different variants of student's simultaneous independent work. The developed software makes the change of teaching possible if the study of the theoretical part or problem solving is not necessary. The credit-rating system of knowledge evaluation is implemented. At the end of the lesson the teacher receives a protocol with the results of students' work which can be used for the analysis of the students' progress in studies and results of the courseware testing. The analysis of these data enables the instructor to assess the students' knowledge as a whole and identify issues which have caused difficulties and build the learning process so as to increase the percentage of the material successfully learned.

Experiment

Interactive physics courseware was piloted in the computer lab of the Department of General Physics, Physico-Technical Institute of Tomsk Polytechnic University during 2000-2010. The piloting of the system involved over 800 people. The courseware allows for the analysis of changes in the students' learning curve from the first lesson (Fig. 3a) to the subsequent ones (Fig. 3b). The result of the analysis performed in 5 groups of students at the Faculty of Machine Building reveals the rise of the learning curve which displays itself as an increase in the number of students who got high scores for the lesson (Fig. 4a,b)). Fig. 4a shows the results of testing different groups of students over three themes. Fig. 4b demonstrates the increase of the grade point average during the physics course study, which confirms the learning curve rise.

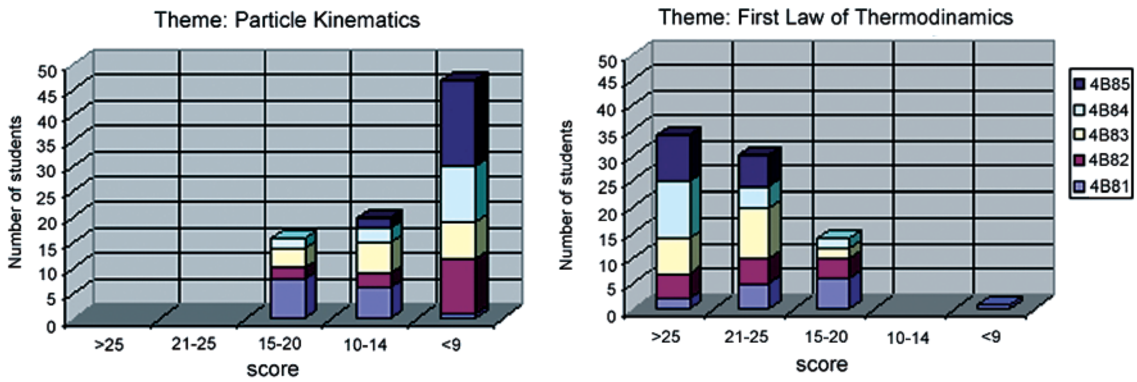

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Fig. 3

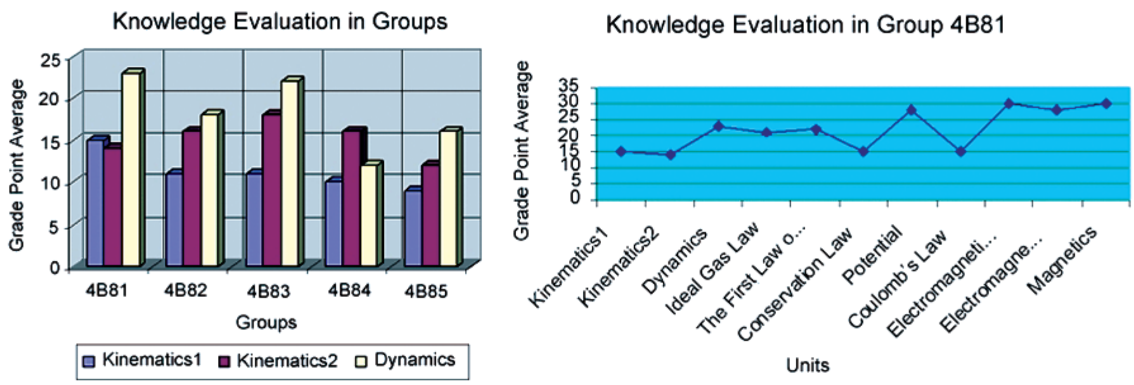

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Fig. 4

Conclusions

Advantages of the interactive courseware:

1. The courseware allows for teaching and simultaneous assessment of knowledge of many students.

2. Due to the software and scientific-methodological support of the courseware all types of knowledge assessment are possible: progress assessment, achievement testing, residual knowledge assessment as well as final examination.

3. Teacher receives an assessment protocol (of a lesson or examination) with the analysis of results of the unit learning.

4. Originality of the test item bank developed by a creative team provokes interest of the test-takers in the process of studies and the testing.

5. The courseware provides for visual expression, intelligibility, comfortable environment of the test item presentation and the process of studies and testing.

6. The courseware allows for teaching and assessment of knowledge in any other discipline if the test questions bank is replaced.

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