New trend in Russian informatics curricula: integration of math and informatics

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Istanbul, Turkey

SAINT-PETERSBURG, RUSSIA

SPb State Electrotechnical University (ETU)

Academy of post-degree pedagogical education

School of Radio Engineering and Telecommunications

School of Information, Measurement, and Biotechnical Systems

School of Computer Science and Technology

School of Electrical Engineering and Automatics

1886

School of Economics and Management

School of Electronics

School of Humanities

- About 10 000 students including 400 international students from almost 40 countries
- Near 1200 academics including 130 Professors, 200 Doctors of Science, and more than 700 Ph.D.s
- About 100 major educational programs and over 40 Ph.D. courses
- 40% of academic curricula are devoted to fundamental disciplines
- Over 1600 BSc, MSc, and Integrated Degree Diplomas every year

STATE BUDGET INSTITUTION OF ADDITIONAL PROFESSIONAL EDUCATION (TRAINING) SPECIALISTS ST. PETERSBURG ACADEMY OF POSTGRADUATE PEDAGOGICAL EDUCATION

- Organization of training and retraining staff of agencies of general and secondary vocational education
- Development of modern training's models
- Scientific and methodological support of the organization and conduct of scientific research, experimental work, in educational institutions, research and consulting activities
- Scientific expertise of models and training programs, guidelines, methodological developments
- Organization of International Cooperation in the field of continuous pedagogical and vocational education
- Certification of teaching staff
- Publishing activity

1863

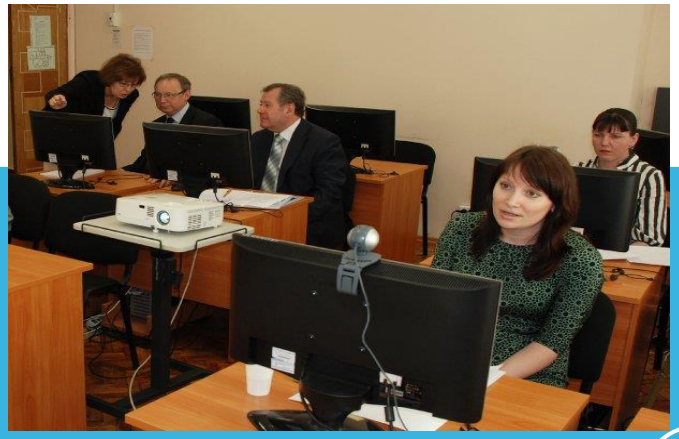
- Pedagogical Museum and Library

1925

- State Institute of Scientific Pedagogy

2003

- Academy of Postgraduate Pedagogical Education



HISTORY OF SCHOOL INFORMATICS IN THE USSR AND RUSSIA

1st stage. 50-70's years of the XX-th century.	
specialized mathematical schools	studying programming

2nd stage. 80's years of the XX century	
introduce in school curricula	period of "paper" informatics

3nd stage. 90's years of the XX century	
emergence of computer classes at all schools	ICT for mathematical education

4nd stage. 00's years of the XXI century	
Emergence of information technology	integration of ICT and informatics

5nd stage. 10's years of the XXI century	
Internet influence	Renaissance programming(web-programming)

HISTORICAL REVIEW OF RELATIONSHIP BETWEEN MATHEMATICS AND INFORMATICS (IN RUSSIAN CURRICULA) -1

1st stage. 50-70's years of the XX-th century. Before the emergence of the school informatics. First computers were installed in some specialized mathematical schools and their students began studying programming. *Integration with mathematics was presented as the application of computing schemes to the solution of mathematical tasks.*

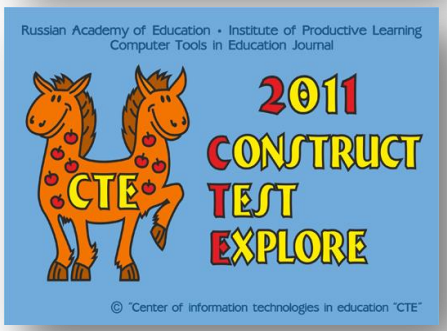
2nd stage. 80's years of the XX century. An informatics were introduced in school curricula. This period wasnamed period of "paper" informatics: schools have not computers and students wrote programs in special algorithmic language in writing-books. *Integration with mathematics during this period was present at the level of representation of numbers, use of formulas, logical functions, the block schemes of algorithms. Subject was taught, as a rule, by the mathematics teacher.*

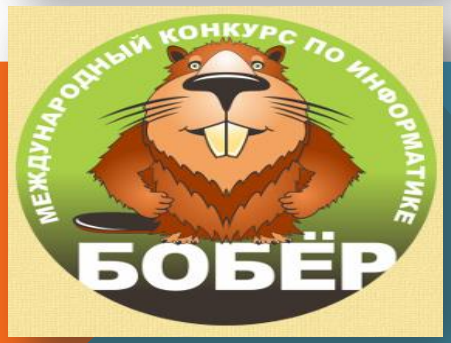
HISTORICAL REVIEW OF RELATIONSHIP BETWEEN MATHEMATICS AND INFORMATICS (IN RUSSIAN CURRICULA) -2

3rd stage. 90's years of the XX century. Emergence of personal computers. The study of algorithms rapidly extended at schools curricula. Interests of pupils started to move from mathematics to programming. So, *the infomatics as a school subject, started to compete with the mathematics*, becoming the main passion for many pupils. During this period, a *dynamic geometry software and a number of programs to manipulate plots of functions were created*.

4th stage. Beginning of the XXI century. The diversity of software leads to a partition of the informatics into two courses that together formed an educational area named "Informatics and ICT". Drop of the interest to programming, that for a long time had been widely connected with the concept of "informatics". Programming was gradually moving to the extracurricular activities. At the same time, one could mark *a tendency in informatics courses to widen the coverage of theoretical informatics such as the information theory*. Extracurricular courses stated to study cryptography.

HISTORICAL REVIEW OF RELATIONSHIP BETWEEN MATHEMATICS AND INFORMATICS (IN RUSSIAN CURRICULA) -3





5th stage. Late 10's of the XXI century. Fast development of the Internet influenced the course of informatics. The Renaissance of the interest to programming was observed because of the web programming. *A prototype of the Unified State Examination (USE) in mathematics, informatics, and popular internet competitions appeared*. The last were used as a way to direct work of teachers to areas in which the course of informatics was going to be extended.

The current stage is characterized by a stabilization of ideas about a proportion between programming and information technologies in the school course of informatics. The new Concept of mathematical education in Russia was discussed, the main idea of its first versions was *to integrate mathematicsand informatics*. In the final version of the Concept this integration is reflected in less extent, but the decision to associate the mathematics and informatics courses is anyway made for the high school (10–17 years old).

CHANGES IN CURRICULA: THE NEW FEDERAL STANDARD

The new standard changes the structure of the basic educational program. It unites the mathematics and informatics subjects in one subject domain "Mathematics and informatics" and defines general requirements to educational results such as

- the development of logical and mathematical thinking,
- an acquaintance with an idea of mathematical models; mastering mathematical reasonings; an ability to apply mathematical knowledge to the solution of various tasks and to estimate the obtained results;
- building skills to solve educational tasks; development of mathematical intuition; developing a picture of information processes in practical situations.

The new standard introduced the two methodological sections in the mathematics curricula: logic and sets. In the existing standard of 2004, a topic "Elements of Combinatorics, Statistics and Probability Theory" was included in the profiling level, but in new standard it is offered to be studied at the basic level.

COMPARISON LIST OF SKILLS THAT ARE TESTED BY THE UNIFIED STATE EXAMINATION (USE) IN MATHEMATICS AND INFORMATICS

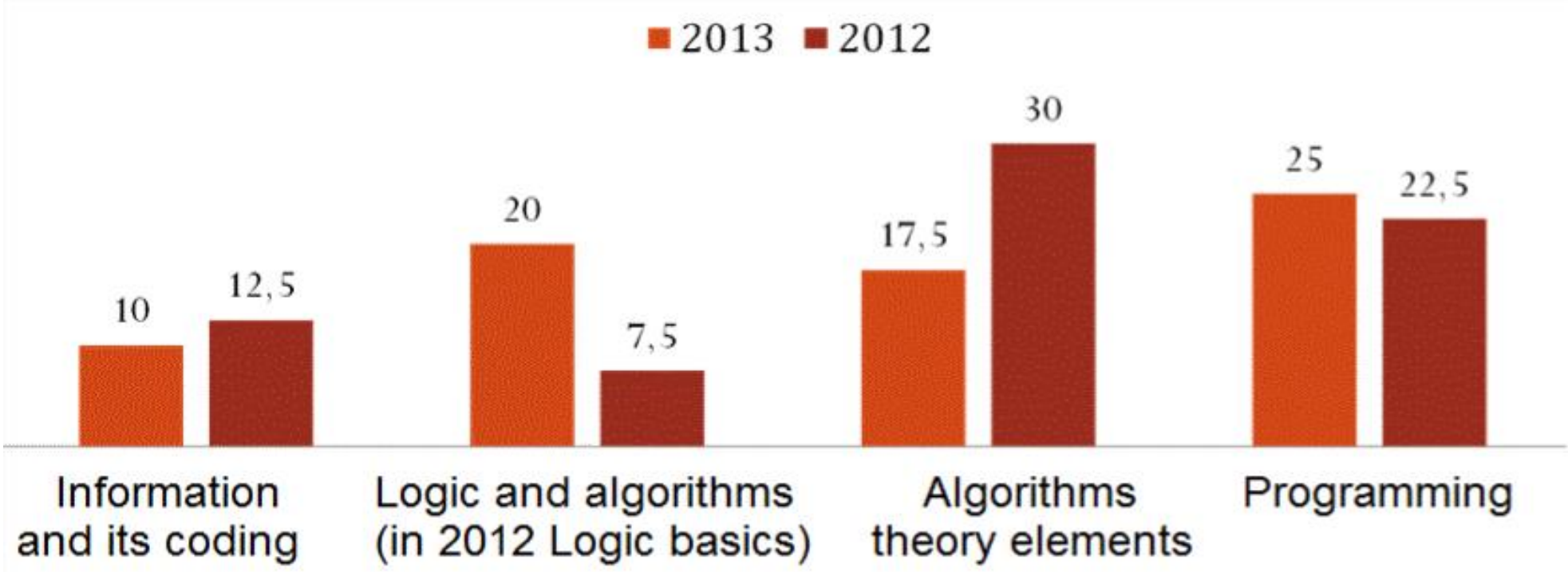
Mathematics	Informatics
– to be able to use the acquired knowledge and abilities in practical activities and everyday life; – to be able to execute computation and conversions; – to be able to solve the equations and inequalities; – to be able to execute actions with functions; – to be able to execute actions with geometrical figures, coordinates and vectors; – to be able to build and research mathematical models.	– simulation of objects, systems and processes; – interpretation of results of simulation; – determination of the quantitative parameters of information processes; – to accomplish information search and selection; – to create and use data storage structures; – to work with widespread automated information systems; – to use the computer for sound processing.

COMPARING OF UNIFIED STATE EXAMINATIONS JOBS IN MATHEMATICS AND INFORMATICS

Units of the mathematics codifier	Number of tasks in mathematics according to the specification	Number of tasks in informatics which require knowledge in corresponding section in math
Algebra	8	30
Equations and inequalities	5	6
Functions	2	6
Elements of combinatorics, statistics and theory probabilities	1	14

Based on the analysis of the demo version of the Unified State Examination of 2014. It is possible to see that only 2 tasks from 32 tasks (less than 10%) on informatics do not require computations.

THE UNIFIED STATE EXAMINATION (USE) AS A METHOD OF REORIENTATION OF TEACHERS ONTO NEW STANDARDS: ANALYSIS OF MATHEMATICS AND INFORMATICS VARIANTS



Distribution of sections weights. In 2014th there were no changes in the distribution of
jobs in comparison with 2013th

PROBLEMS OF INTEGRATION OF MATHEMATICS AND INFORMATICS AND DIRECTION OF THEIR POSSIBLE SOLUTION

Problem 1. One of the important problems is the insuciency of ideas of the discrete mathematics and theoretical informatics in the traditional course of mathematics. There is a need to expand the mathematics course by adding new sections of the discrete mathematics.

How to do it without exceeding the volume of mathematics within the curricula?

SOLUTIONS PROPOSED FOR PROBLEM 1

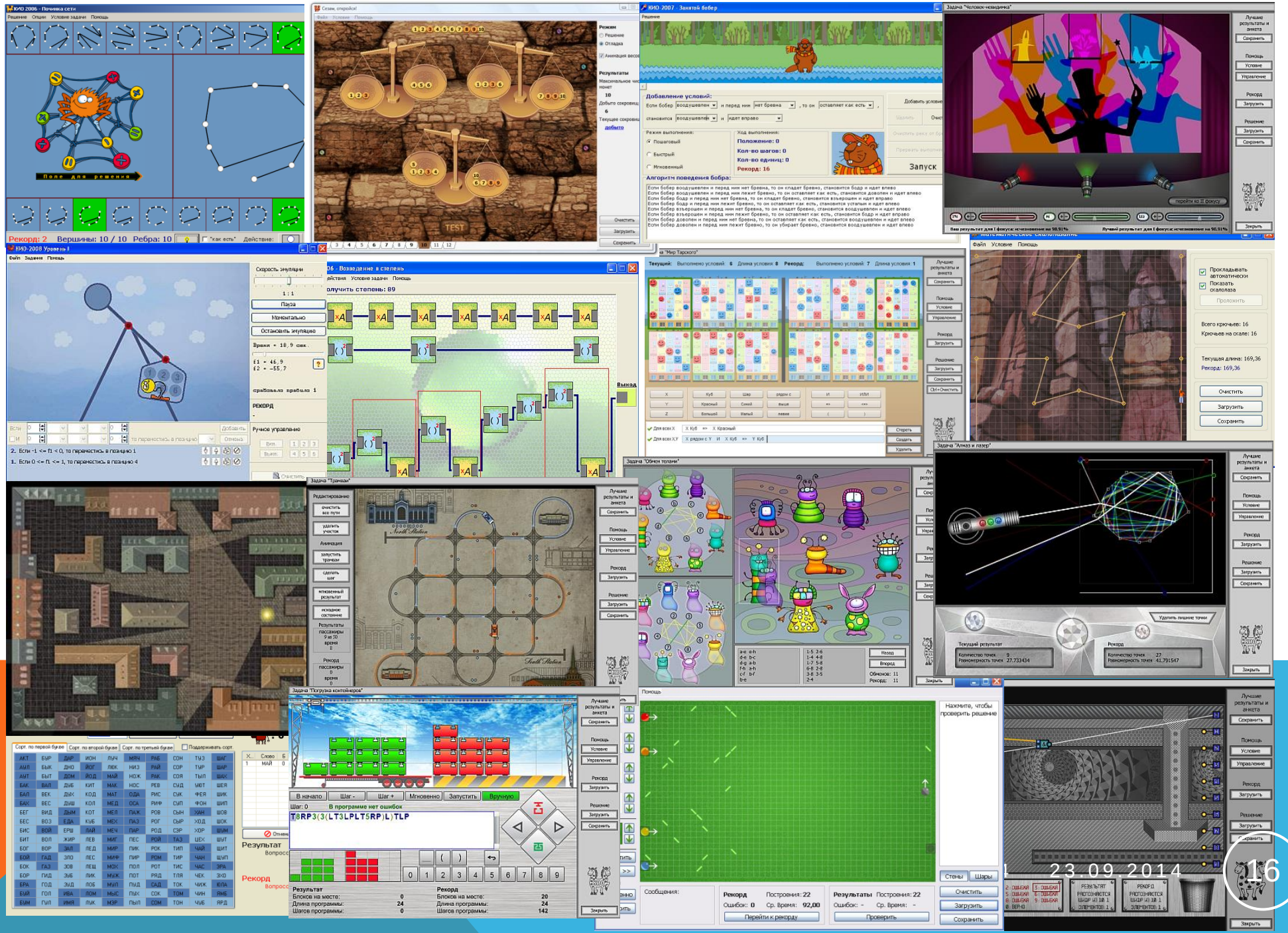
The changing of the curricula in the modern conditions can start in the supplementary education. Supplementary education in new Russian standards is considered as a mandatory part of the school training.

As an example of such an approach in Russia we present the competition “Construct, Test, Explore”. Every year three special educational laboratories are created on the basis of this project. These laboratories propose an active approach to master new fundamental ideas of informatics and discrete mathematics.

THE EXAMPLES OF EDUCATIONAL MODULES IN DISCRETE MATHEMATICS AND INFORMATICS CREATED FOR THE RESEARCH ON THE BASIS OF THE "CONSTRUCT, TEST, EXPLORE"

1. Is it possible to compute without consuming energy? (Billiard computer by Fredkin and Tooli)
2. Post's lattice of boolean clones and their bases
3. Boolean schemata for pattern recognition
4. Shannon entropy in communication
5. Fermat's principle in the search for the shortest path
6. Laws of interaction in an ensemble of particles
7. Optimization of routes in a graphs (a transport network)
8. Functional sorting
9. Calculations optimization
10. Gears and continued fractions: clock-calendar
11. Getting acquainted with the knot theory
12. Transformation groups and decomposition of complex transformations
13. NP-complete problems (variations of a traveling salesman problem)
14. Euclid algorithm and its generalizations (pouring fluids)
15. Finite automaton and the Turing Machine
16. Pendulums and the control of complex oscillations
17. Algorithms for programming devices

KALEIDOSCOPE OF CTE EDUCATIONAL LABORATORIES



PROBLEMS OF INTEGRATION OF MATHEMATICS AND INFORMATICS AND DIRECTION OF THEIR POSSIBLE SOLUTION

Problem 2. The first problem is closely connected with the problem of how to save mathematical culture while modifying the curricula. The mathematical culture is traditionally based on the contents verified and optimized during many years. The changes of the subject contents should not deplete the means of formation of the intelligent mechanisms of the trainee.

SOLUTIONS PROPOSED FOR PROBLEM 2

Note that the traditional basis for the formation of mathematical concepts is based on the external environment, that significantly changed during recent years. An important role in the student's habitat is now played by computers and the Internet.

So, it is necessary to explain the laws of a noosphere along with an explanation of the laws of the nature: how surrounding artificial subjects are arranged and how they work. It is a source of new interpretations of that general concepts which are already present in the mathematics.

We should increase a "weight" of the general concepts which have clear virtual presentations (for example, geometrical conversions, polynomials, long numbers, logic expressions, formal grammars).

PROBLEMS OF INTEGRATION OF MATHEMATICS AND INFORMATICS AND DIRECTION OF THEIR POSSIBLE SOLUTION

Problem 3. The third problem is the continuity problem.

How should changes be done to switch to the new contents smoothly?

Whether it is possible to use a traditional material to create the new representations relevant for the modern reality?

SOLUTIONS PROPOSED FOR PROBLEM 3

Solutions proposed for Problem 3. The support of the continuity of math courses can be achieved by new interpretations of the traditional mathematical curricula.

For example ideas of multiplication and factorization of integers naturally receive interpretations in terms of complexity of algorithms, and lead to basic cryptography ideas.

The study of operation with polynomials and other symbolic (algebraic) object can be based on the question of “how these operations are executed inside the computer”.

The ideas of the formulas description through syntax trees naturally arise, and then an analysis and interpretation of operations with formulas through operations on trees become possible.