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Strategy for ICT Skills Teachers and Informatics Olympiad Coaches Development

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Abstract. The raising of interest in pupils to study informatics and become involved in informatics olympiads in many respects depends on the qualification of teachers and the coaches who are engaged in the search and preparation of pupils for informatics olympiads. The analysis of tendencies of development in the Russian and international informatics competition over the last 10 years, and programs of informatization of schools in Russia, has allowed three levels of informatics and informational communication technologies (ICT) to be defined for the preparation of school teachers in Russia. In the given article these levels of ICT preparation of school teachers in Russia and their link among themselves are described. Organization of the preparation of teachers, taking into account characteristic features for each level, will allow the essential quantity of participants of the informatics olympiads to increase and will raise the results of their involvement in the Russian and international informatics olympiads.

Key words: secondary school education, informatics and informational communication technologies skills of teachers, Olympiads in informatics, IOI, informatization of education system, state educational programs, ICT competence of teachers.

1. Introduction

The Russian Government has put education in the 2001 national policy priorities and has revitalized active realization of projects of Russian education informatization. The state concept of Russian education modernization (2000–2010) additionally became a basis for the development of informatics and informational communication technologies (ICT) in secondary schools and a social activity of youth peoples of Russia.

A very important result of the fulfillment of "The State concept of Russian education modernization (2000–2010)" was a statement in 2004 of the state school educational standard which is now (2009–2010) being updated. Before 2004 there was only a minimum literacy level for school subjects which was updated every 5 years. Now the state school educational standard includes complex curricula for all school educational fields

(math, natural sciences and informatics, philology and humanities sciences, technology and art), mandatory requirements for teaching pupils and conditions of teaching process (list of equipment for school), supplies and materials for school (Federal book list for school subject).

Now the state school educational standard has introduced to schools a number of new problems:

1. To develop the interest of students in new information technologies.
2. To guarantee the creation of ICT competence for students on the basis of an informatics course.
3. To reveal talented students in the area of informatics on the basis of an open school stage of the Russian Olympiad in Informatics.
4. To give the possibility for talented pupils to prepare for the final stages of the Russian Olympiad in Informatics.
5. Actively to co-operate between schools and to offer to the students the professional-oriented elective courses from coaches in different schools over the Internet.
6. Effectively to use the informational space of school.
7. Actively to use ICT competence of pupils in training various school subjects.

For solution of these problems it is necessary to generate teachers' ICT. Obviously problems 1–3 are realized by the informatics teacher at school. Their professional competences are completely defined by the state standard in the informatics course at school. A description of the curriculums of school informatics courses, at the basic and professional-oriented levels, are presented in the article (Kiryukhin, 2010). It is exactly these informatics teachers that help to reveal talented pupils in informatics by means of an open school stage of the Olympiad in Informatics in Russia. In this case the competences of comprehensive school informatics teachers are developed together with standard state update in informatics every 5 years.

For solving problems 4–5 it is especially necessary to select coaches from among informatics teachers. These are those teachers who prepare students for involvement in the final stages of the Russian Olympiad in Informatics. The solution of task 4 by schools requires the development of curricula for the special ICT preparations of informatics teachers-coachers. The curriculum of preparation of such teachers-coachers is described for the first time in this article on the basis of the analysis by the authors of the competition task content of the Russian and International Olympiads in Informatics for the last 10 years. This curriculum expands the standard topics on informatics for schools, and also includes topics on mathematics, logic, and programming. On the basis of additional preparation topics the teacher can form elective courses for students grades 9–11 as professional-oriented training at high school. Above all these topics in the curriculum automatically become topics in specialized courses for students – future participants of the Olympiad in Informatics.

Speaking about education informatization it is impossible to forget the teachers who are not teaching informatics at school. Such teachers are the majority at comprehensive school and they should be ICT competent to effectively use the informational environment of school in partnership with pupils. Such partnership with ICT competent teachers

in various school subjects will allow ICT active pupils to develop in other school subjects, with advanced ICT usage and help define the future profession. Finally, problems 6–7 require solving unification of common ICT competences for schools teachers.

From what is mentioned above it follows that the level of ICT preparation for school teachers in various subjects should be different. It causes difficulties for ICT, teaching them and the organization of pedagogical partnership of students and teachers in using ICT, especially for the students who have been carried away from informatics. The school should not only reveal the ICT talented students, but also support ICT with other school subjects and give students a chance in their future occupation to use high information technologies. The school's task is to help talented pupils be prepared for innovative activities, including those with usage high ICT.

2. Levels of ICT Preparation of School Teachers in Russia

The analysis of the state school educational standard and contents of the competition tasks of the Russian and International Olympiads in Informatics for the last 10 years has allowed the allocation of three levels of ICT preparation for school teachers in Russia:

1. The level of ICT preparation of each teacher in comprehensive school.
2. The level of ICT preparation of informatics teachers for improving their professional skills.
3. The level of preparation of informatics teachers and coaches who will prepare students for involvement in the final stages of the Russian Olympiad in Informatics.

The first level of ICT preparation concerns each comprehensive school teacher. This level is common for all teachers. This level sets common ICT competences for teachers of different school subjects. The common ICT competence of teachers shows a degree of partnership with teachers and pupils in the informational environment of a school. It is possible to name this level the informational culture of the teachers. This level of teacher preparation is very important so that pupils can apply ICT abilities to different subjects at school. The ICT abilities of pupils are formed by informatics teachers at school.

The second level of ICT preparation is connected with professional skills teachers of informatics in Russia. This level of preparation of informatics teachers is defined by the state school educational standard on informatics, which is refreshed every 5 years. The contents of the informatics course was developed for the Russian schools in 1998. After that, in 2004, the state school education standard including informatics and ICT was accepted (Kiryukhin and Tsvetkova, 2008). Currently the new standard is being prepared for acceptance in 2010 which will update the informatics and ICT program of preparation of teachers to include new achievements in informatics and information technologies.

The third level is the highest level of preparation for informatics teachers. It is the preparation among informatics teachers of those who will be training students for participation in final stages of the Russian Olympiad in Informatics or the IOI. This level of preparation is defined by the contents of modern competition tasks and international informatics olympiads. The curriculum, developed by the authors of this paper, is based on

analysis of the Russian Olympiads in informatics contents (Kiryukhin, 2007; Kiryukhin, 2008) and the contents of IOI competition tasks (Verhoeff *et al.*, 2006; Kiryukhin and Okulov, 2007) over the 10 last years and programs of informatization of schools in Russia.

It is necessary to notice, that all three levels of ICT preparation of informatics teachers in comprehensive school are connected among themselves (Tsvetkova, 2008). As a result it is reflected in pupils' successful lives in the informational world; it especially concerns talented pupil in the field of informatics and their state support in an education system. It also influences the ICT activity of pupil in study, creative development and professional orientation.

As mentioned above the second level of preparation of informatics teachers is defined by state school educational standards of informatics and ICT or by similar documents on which the basis the informatics or computer science at comprehensive schools is studied. It is abundantly clear, that in every country there are features of such preparation of informatics teachers and it is not necessary to speak in this case about any general approach. Therefore we will only consider the preparation of teachers at the first and third levels. As to the ICT preparation of informatics teachers in Russia, these questions are in detail described in paper (Kiryukhin, 2010).

3. Common ICT Competences (Skills) of Comprehensive School Teachers

Experience has shown it is possible to consider that the modern common ICT competence of comprehensive school teachers is *the closest development area to professional teachers' skills*. This closest development area demands mandatory equipment: a teacher workstation by the computer and such ICT resources (including new digital equipment and special software), as to form the tool making computer system (TCS) of professional teacher activity which is a part *of the informational space of education.* A very important role in TCS belongs to the Internet educational resources which are already broadly used by comprehensive school teachers in Russia. Some examples of such Internet educational resources are the following:

- Federal system of informational educational resources (FSIOR, 2008; WE, 2007);
- Informational system of state certification (EGE, 2009);
- Informational content training system for secondary schools "KM-School" (KMS, 2009);
- Informational content training system for primary schools (Nachalka, 2009);
- Distance training system "Teleschool" (Teleschool, 2009);
- On-line methodical support system of teachers in informatics (MSSTI, 2008);
- Open interactive educational Internet-video channel for teachers (I-NetVC, 2008);
- Social network for teachers (SNT, 2009);
- Social contents network for schools (SCNS, 2009);
- Children's social network "Bibigon" (Bibigon, 2009);
- Open school encyclopedia by Cyril & Methodius (CM, 2009);

- Open web-practice in informatics (OWPI, 2008).

Since the partnership of teachers and students taking place is the basis of ICT usage in various school subjects, it is necessary to provide a common ICT competence of teachers across school subjects. The contents of such common ICT preparations correspond to the following:

1. Presence of the general understanding of didactic abilities of ICT.
2. Presence of understanding of uniform information space of educational institution, purpose and functioning of computer, devices for input-output of the information, computer networks and the opportunities of using them in educational process.
3. Skills in the organization of personal information environment, the interface of operating system, performance of file operations, organization of the information-educational environment as file system, the basic techniques of input-output of the information including installation and removal of applications.
4. Skills in preparation of didactic materials and briefs according to a subject curriculum by means of office technologies (distributing materials, presentations, etc.):
   - 4.1. Text input with the keyboard and techniques for text formatting.
   - 4.2. Preparation of the distributing materials containing graphic elements, typical methods of work with vector graphics tools.
   - 4.3. Methods of working with tabulated data (making lists, information cards, simple calculations).
   - 4.4. Methods of creating graphics and diagrams.
   - 4.5. Technique of creation of pedagogically effective presentations (for a lesson, a statement on teachers' meeting, a report etc.).
5. Availability of base services and technologies of the Internet in a context of its use for educational activity:
   - 5.1. Methods of navigation and search of the educational information in the Internet, its reception and saving for subsequent using in pedagogical process.
   - 5.2. Methods of work with e-mail and teleconferences.
   - 5.3. Methods of work with file archives.
   - 5.4. Methods of work with ICQ (AOL, etc) and other communication technologies.
6. Skills in the technological basis of site creation for a teacher's portfolio:
   - 6.1. Availability of understanding of purpose, structure, tools of navigation and design of a site for support of educational activity;
   - 6.2. Availability of understanding of web-page structure;
   - 6.3. Skills in simple methods of site-making which allow the representation of educational information in the form of a site;
   - 6.4. Skills in methods of Intranet and Internet publications for a site for educational activity.
7. Knowledge of digital educational resources and trends in the market of electronic editions in the sector of general education, focused on subject-professional work, and the digital educational resources executed during realization of Federal education informatization programs.

8. Skills in basic usage techniques of digital educational resources in teaching and educational process.
9. Availability of understanding of technologies and resources for distance educational processes and of the possibilities of using them in pedagogical activity.

4. The Common Curriculum of Improvement Comprehensive School Teachers

The common curriculum for the improvement of comprehensive school teachers has been developed on the basis of the analysis of various variants of similar programs in the following projects: "Teacher to the future" (Intel, 2003), "Academy of teachers" of the international initiative Microsoft "Partners in learning" (SNT, 2009), "Informatization of education system" (Tsvetkova *et al.*, 2005) and also the programs of many ICT training centers in regions of Russia (MSSTI , 2009). All these programs have variations in their contents, taking into account own aspects of training.

It is important that in worked out curriculum it is summarized the experience of all programs for last 5 years. Some parts are revealed invariants for all teachers of comprehensive school, they help to allow the development of the common information culture of teachers, subject to their level of computer literacy (Tsvetkova, 2009; 2010).

The common curriculum of improvement for comprehensive school teachers consists of 6 typical modules for the preparation of school teachers by the common ICT competences described above. No module exceeds 18 hours of training. To each kind of competence there is a corresponding part of the program of training. It is important to notice, that each module is focused on ICT competence in educational activity. This feature of the curriculum allows a teacher to reach competence in the field of ICT, not on user level, and on a professionally oriented level in the sense of embedding ICT in pedagogical practice.

The common curriculum of improvement for comprehensive school teachers is represented in Table 1. It is oriented at 72 hours of studying. Of them 26 hours are connected with theory and 48 hours with practice. Modules 1, 2 and 3 make a course of the computer literacy and last 36 hours. Modules 4, 5 and 6 make a course of the common information culture of the teacher and it also lasts 36 hours. For groups of teachers possessing computer literacy, it is possible to use the curriculum on the basis of 36 hours of a common information culture course and 36 hours of the additional module 7 (updated modules 1–3). Topics which can be replaced with the additional module 7 are defined on the basis of primary testing of teachers. It is offered on those topics on which a teacher demonstrated competent after testing, to promote his trajectory of development in the ICT school environment with use of the additional module.

The content of each part of training is realized both though lectures and a practical training, in the form of computer practical work and in the form of workshops. Workshops are practical lessons in the form of discussions that do not demand the use of computers. Such lessons are recorded on video and participants can repeat them again and again for better understanding. The purpose of workshops is to search for optimum techniques for carrying out of lessons for various groups of teachers on the basis of using

Table 1

Typical modules of the curriculum "The common ICT competence of teachers"

Modules of the curriculum			Class periods		
			In total	Lectures	Seminars, practical employment (occupations)
1.	**Introduction in ICT**		**4**	**4**	
	1.1	ICT-preparation in the structure of pedagogical activity **(skill 1)**	2	2	
	1.2	Workshop of teachers "Concept of uniform information space of educational establishment, model of its construction, teacher's personal information space". **(skill 2)**	2	2	
2.	**The organization of a teacher workplace with use of computer (skill 3)**		**14**	**4**	**10**
	2.1	The organization of teacher's personal information space and computing work station	4	2	2
	2.2	Introduction in Microsoft Windows / Linux	4		4
	2.3	The general questions of a technique of introduction of digital equipment in teaching and educational process (interactive board, digital laboratory, computer models)	4	2	2
	2.4	Practical work. The tool making computer system (TCS) of professional teacher activity which is a part of the informational space of school (the school schedule, the electronic journal of lessons)	2		2
3.	**Methodical bases of preparation of evident and didactic materials means ICT (skill 4)**		**18**	**6**	**12**
	3.1	Methods of preparation of didactic materials (on example Microsoft Word / Open office)	4	2	2
	3.2	Methods of preparation of didactic materials (on example Microsoft Excel / Open office)	4	2	2
	3.3	Preparation of the distributing materials containing graphic elements	2		2
	3.4	Methods of preparation of evident means and educational-methodical materials (on example Microsoft PowerPoint / Open office)	4	2	2
	3.5	*Practical work "Creation of evident and educational-methodical materials by Microsoft Office/ Open office means "*	4		4
4.	**The Internet in educational activity (skill 5)**		**12**	**4**	**8**
	4.1	Bases of construction of the Internet network. Internet-channels, main principles of work of satellite segment, the uniform Educational Information Space. Educational opportunities of services of the Internet network	1	1	
	4.2	Information search systems in the Internet network in the activity of the teacher and pupils	2		2
	4.3	*Educational resources of the Internet (the review and thematic search)*	2		2
	4.4	Informational protection systems	2	1	1
	4.5	*e-mail of support of educational activity*	3	1	2
	4.6	Legal aspects of the use of the software and Internet – resources in education. License agreements. Free software	2	1	1

To be continued

Continuation of Table 1

Modules of the curriculum			Class periods		
			In total	Lectures	Seminars, practical employment (occupations)
5.	**The Internet for teacher's portfolio (skill 6)**		**12**	**4**	**8**
	5.1	Introduction in technology of creation of Web-sites of educational purpose with tools of site constructor and by the example of HTML language use	4	2	2
	5.2	Network educational communities and projects	2	2	
	5.3	Remote support of educational process. Network association of methodologists	2		2
	5.4	*Practical work "Creation of a breadboard model of a site – teacher's portfolio"*	4		4
6.	**Digital educational resources in pedagogical activity (skill 7–9)**		**12**	**4**	**8**
`	6.1	The review of the digital educational resources executed during realization of Federal target programs **(skill 7)**	4	2	2
	6.2	Workshop of teachers "Designing of a lesson with use of digital educational resources"**(skill 8)**	2	2	
	6.3	Activity of the teacher groups in the school distance training space with students studying at home **(skill 9)**	2		2
	6.4.	*Additional practical work on use digital educational resources (DER) in training the subjects of the curriculum (in groups) on example of the* DER *of the school media library*	4		4
In total:			**72**	**26**	**48**
7.	***Additional Variation modules (Updated skills 1–4)***		***36***	***14***	***22***
	7.1	Specificity of education cooperation the context of work teachers with students. School project teams. Learning ICT-project (in school subject) Workshop of teachers "School ICT center for home work. School Internet club/ICT club for family"	6	4	2
	7.2	Technology organization computer help service in the school as student's ICT-team	6	2	4
	7.3	Technology organization school publishing student's team	6	2	4
	7.4	Technology organization web-studio in school as student's web-team	6	2	4
	7.5	Technology organization school computer club with digital laboratory	6	2	4
	7.6	Technology organization the school video-studio as student's TV-team	6	2	4

ICT resources. Such workshops are significant for searching for new techniques for the preparation of each comprehensive school teacher on the basis of distant technologies and for development of socially useful school projects.

In Table 1 typical modules of the common curriculum of preparation of comprehensive school teachers are presented. Variation themes for the teachers on different school subject are indicated by italics.

The further development of the described curriculum can be realized by the addition of 18 hours of new modules, taking into account new spheres of ICT application to teaching practice. For example modules 1–2 and module 3 in the computer literacy course will soon pass into an area of self-reliant study by teachers if they become proficient in computer literacy.

The decade 2010–2020 becomes a decade of development of information culture of teachers. The major role during this period will be distant education technologies on a basis the Internet, TV-technologies and interactive media resources (I-NetVC, 2009), (MSSTI, 2009). The big developments will be in the computer workplace of the teacher and the digital lab ware. The common ICT culture of teachers will be the mastering of tools of lesson design and a management system for educational processes. The information space of school will be transformed to interschool information system.

All of this will demand comprehensive mastering by teachers of the common ICT competences and system development of their information culture in the uniform information space of education. In this case new modules of training should build-in a flexibly, for each teacher, in the trajectory of development of information culture.

5. The Complex Curriculum of Preparation of Informatics Teachers and Coaches in Olympiad Informatics

Preparation of informatics teachers and coaches in informatics olympiads on the one hand should be based on the state school educational standard on informatics and on the other hand should take into account the modern competition tasks contents of national (Kiryukhin, 2008; 2009) and international (Verhoeff *et al.*, 2006; Kiryukhin and Okulov, 2007) informatics olympiads. The analysis of the currently enforced state school educational standard on informatics in Russia (Kiryukhin, 2010) has suggested a complex curriculum of preparation of informatics teachers on based on their professional ICT competence.

Taking into account the approach described in the paper (Kiryukhin, 2007) defining the contents of the Olympiad on Informatics we will select the following key parts of the complex curriculum of preparation of informatics teachers and coaches in informatics olympiads:

1. Mathematical Fundamentals of Informatics.
2. Developing and Analyzing of Algorithms.
3. Programming Fundamentals.
4. Computer Literacy.
5. Operating Systems.
6. Basis of Programming Technology.
7. Fundamental Methods of Calculations and Modeling.
8. Introduction to Network Technologies.

Taking this into account, the complex curriculum presented below for the preparation of informatics teachers and coaches in informatics olympiads consists of eight sections,

each of which reveal sub-topics. Each topic in turn contains, in more detail, the didactic units revealing key knowledge and skills that allow for each student to draw up an individual trajectory of preparation for the Olympiad in Informatics.

Each didactic unit has a certain level of complexity to which readers will be given guidance. In particular, three levels of complexity are selected, marked as follows:

- didactic unit without "*" – means that it concerns initial level of complexity (the first level), and the knowledge of these didactic units allows pupils to take part in school and municipal stages of the Russian Olympiad in Informatics;
- didactic unit with "*" – means a level of preparation sufficient for successful performance at regional stages of the Russian Olympiad in Informatics (the second level of complexity), provides practical and conceptual level of requirements to the participant of informatics olympiad, allows intelligently to come to solution of competition tasks and provides with it possibility technologically to present the own ideas;
- didactic unit with "**" – means the third level of complexity; additional studying of these didactic units forms key abilities for students for solving competition tasks, opens before the olympiad participant the possibility to show the creative potential and to get solutions of enough complex competition tasks which are offered at a final stage of the Russian Olympiads in Informatics and the IOI, allows the filling of student portfolio achievements with diplomas of winners or prize-winners of the final stages of the Russia Olympiad in informatics and the IOI.

Taking into account the above, the mentioned complex curriculum of preparation of informatics teachers and coaches on informatics olympiads will look like the following.

1. Mathematical fundamentals of informatics
   - 1.1. Functions, relations and sets
     - 1.1.1. *Functions, inverse functions, composition*
     - 1.1.2. *Relations (reflexivity, symmetry, transitivity, equivalence, lexicographical order)*
     - 1.1.3. *Sets (Venn diagrams, complements, Cartesian products)*
     - 1.1.4. *Well-ordered sets **
     - 1.1.5. *Cardinability and countability ***
   - 1.2. Basic geometry
     - 1.2.1. *Point, line, segment, vector, angle*
     - 1.2.2. *Cartesian coordinate system in Euclidean space*
     - 1.2.3. *Euclidean distance*
     - 1.2.4. *Cross-product and scalar product on the plane*
     - 1.2.5. *Triangle, rectangle, polygon*
     - 1.2.6. *Convex polygons*
     - 1.2.7. *Trigonometric functions and formulae **
     - 1.2.8. *Voronoi diagram and Delaunay triangulation ***
   - 1.3. Basic logic
     - 1.3.1. *Logic variables, operations, expressions*
     - 1.3.2. *Truth tables*

1.3.3. *Boolean functions*
1.3.4. *Universal and existential quantification*
1.3.5. *Ways to describe Boolean functions*
1.3.6. *Transformation of logical expressions*
1.3.7. *Normal forms (conjunctive and disjunctive) **
1.3.8. *Minimizing Boolean functions **
1.3.9. *Axiomatic of propositional logic **
1.3.10. *Predicate logic **

1.4. Basics of counting

1.4.1. *Counting arguments:*

- *Sums and product rule*
- *Arithmetic and geometric progressions*
- *Fibonacci numbers*
- *Inclusion-exclusion principle **

1.4.2. *Recurrent relations*
1.4.3. *Matrices and matrix operations **
1.4.4. *Fast multiplication of numbers or matrices ***

1.5. Proof techniques

1.5.1. *Direct proofs*
1.5.2. *Drawer principle*
1.5.3. *Proof by counterexample*
1.5.4. *Proof by contraposition*
1.5.5. *Proof by contradiction*
1.5.6. *Mathematical induction*
1.5.7. *The structure of formal proofs **

1.6. Basics of theory of number

1.6.1. *Prime numbers, Fundamental Theorem of Arithmetic*
1.6.2. *Division with remainder*
1.6.3. *Greatest common divisor*
1.6.4. *Co-primes*
1.6.5. *Divisibility. Residue ring **
1.6.6. *Chinese remainder theorem **
1.6.7. *Primitive roots and discrete logarithms ***

1.7. Basics of algebra

1.7.1. *Polynomials and operations with them. Solving quadratic equations. Viet theorem*
1.7.2. *The general case of Viet theorem. Symmetric polynomials **
1.7.3. *The concept of group ***
1.7.4. *Groups properties ***
1.7.5. *Normal subgroups ***
1.7.6. *Theorems about homomorphism and isomorphism ***

1.7.7. *Using group theory to solve combinatorial problems* **

1.8. Basics of combinatorial calculus

1.8.1. *Permutations, arrangements and combinations:*

- *Basic definitions*
- *Pascal's rule*
- *Binomial theorem*

1.8.2. *Grey codes: subsets, combinations, permutations* *

1.8.3. *Inverse tables* *

1.8.4. *Sets partitioning. Stirling numbers* *

1.8.5. *Parentheses sequences* *

1.8.6. *Connection between parentheses sequences and other combinatorial objects (binary and rooted trees, triangulations etc.)* **

1.8.7. *Estimating numbers of combinatorial objects. Stirling's formula. Corollaries.* **

1.9. Graph theory

1.9.1. *Kinds of graphs*

1.9.2. *Paths and connectivity*

1.9.3. *Operations with graphs*

1.9.4. *Trees*

1.9.5. *Spanning trees*

1.9.6. *Graph coloring*

1.9.7. *Eulerian and Hamiltonian graphs*

1.9.8. *Graph covering and independent sets* *

1.9.9. *Planar graphs and graph layout* *

1.9.10. *Biconnectivity. Bridges, articulation points* *

1.9.11. *Connection between DAGs and order relations. Transitive closure* *

1.9.12. *Bipartite graphs* *

1.9.13. *Flows and networks* *

1.9.14. *Planning network graph* *

1.9.15. *k-connectivity* **

1.10. Basics of probability theory

1.10.1. *Probability and expectation. Axiomatic of probability theory* *

1.10.2. *Total probability lemma and Bayes formula. Conditional probability and expectation* **

1.10.3. *Generating random objects for testing* **

1.10.4. *Approximate optimizing methods* **

1.11. Basics of games theory

1.11.1. *Game, the result of the game*

1.11.2. *Basic games and strategies*

1.11.3. *Sprague-Grundy function* *

1.11.4. *Matrix games* **

1.12. Linear programming
- 1.12.1. *Linear programming problems. Geometrical interpretation **
- 1.12.2. *Basic methods of solving linear programming problems: simplex method, table interpretation ***
- 1.12.3. *Duality ***
- 1.12.4. *Examples of linear programming problems: maximum flow, assignment problem, shortest path ***
- 1.12.5. *Discrete linear programming ***

1.13. Basics of mathematical analysis
- 1.13.1. *Derivative and integral. Evaluating the area **
- 1.13.2. *Green formula ***

1.14. Automatons and grammars
- 1.14.1. *Finite automaton ***
- 1.14.2. *Connection between finite automatons and grammars ***
- 1.14.3. *Using finite automatons ***
- 1.14.4. *Normal forms ***

2. Developing and analyzing algorithms

2.1. Algorithms and their properties
- 2.1.1. *The concept of algorithm*
- 2.1.2. *Properties of algorithms*
- 2.1.3. *Non-formal notation of algorithms*

2.2. Data structures
- 2.2.1. *Basic data structures*
- 2.2.2. *Sets*
- 2.2.3. *Sequences*
- 2.2.4. *Lists*
- 2.2.5. *Non-directed graphs*
- 2.2.6. *Directed graphs*
- 2.2.7. *Trees*
- 2.2.8. *Heap and RMQ/RSQ tree**
- 2.2.9. *Fenwick trees and their n-dimensional implementation **
- 2.2.10. *Balanced trees **
- 2.2.11. *Hash tables and associative arrays **
- 2.2.12. *Trie ***
- 2.2.13. *Suffix tree ***

2.3. Basic algorithmic analysis
- 2.3.1. *Big O notation*
- 2.3.2. *Complexity sets*
- 2.3.3. *Asymptotic analysis of upper and average complexity bounds*
- 2.3.4. *Balance between memory and run-time complexity **
- 2.3.5. *Using recurrent relations to analyze recurrent algorithms **

2.3.6. *NP-complexity* **
2.3.7. *Computability* **
2.3.8. *Universal algorithms and self-applicability problem* **
2.3.9. *Matroid theory* **

2.4. Algorithmic strategies

2.4.1. *Brute force*
2.4.2. *Greedy algorithms*
2.4.3. *Divide et impere* *
2.4.4. *Backtracking* *
2.4.5. *Heuristics* *
2.4.6. *Branch-and-bound method* **
2.4.7. *Simulated annealing* **
2.4.8. *Four Russians speed-up* **

2.5. Recursion

2.5.1. *The concept of recursion*
2.5.2. *Recursive mathematical functions*
2.5.3. *Simple recursive functions*
2.5.4. *Implementing recursion*
2.5.5. *Divide et impere* *
2.5.6. *Backtracking* *

2.6. Basic computational algorithms

2.6.1. *Simple numeric algorithms*
2.6.2. *Classical combinatorial algorithms*
2.6.3. *Subset algorithms: generating all, generating next and previous, obtaining number and obtaining by number*
2.6.4. *Combinations and permutations algorithms: generating all, generating next and previous, obtaining number and obtaining by number*
2.6.5. *Linear and binary search*
2.6.6. *Quadratic sorting algorithms (selection, insertion)*
2.6.7. *Counting sorting*
2.6.8. *O(N log N) sorting (Quicksort, heap sort, merge sort)* *
2.6.9. *Digital sort* *
2.6.10. *Obtaining word number in lexicographically ordered set of its letters permutations* *
2.6.11. *Arbitrary-size arithmetic* *

2.7. *Numeric algorithms*

2.7.1. *Integer factorization*
2.7.2. *Eratosthenes sieve*
2.7.3. *Euclid's algorithm*
2.7.4. *Extended Euclid's algorithm. Implementing without division**
2.7.5. *Solving linear modular equations using Euclid's algorithm* *
2.7.6. *Effective implementation of Eratosthenes sieve (O(n))* *

2.7.7. *Gaussian method and matrix inversions* **
2.7.8. *Fast power calculations. RSA* **
2.7.9. *Discrete logarithms* **
2.7.10. *Roots modulo n* **
2.7.11. *Effective primality test* **
2.7.12. *Fast factoring algorithms. Rho heuristics* **
2.7.13. *Berlekamp's algorithm* **

2.8. String processing

2.8.1. *Search for substring. Naïve method*
2.8.2. *Linear substring algorithms (Knuth–Morris–Pratt, Z-function)* *
2.8.3. *Cyclic strings* *
2.8.4. *Editorial distance and optimal alignment* *
2.8.5. *Boyer–Moore algorithm* **
2.8.6. *Aho–Corasick algorithm* **
2.8.7. *Building suffix trees* **
2.8.8. *Digital suffix sorting* **
2.8.9. *Prime strings, string factorization* **
2.8.10. *Building suffix automatons* **

2.9. Graph algorithms

2.9.1. *Breadth- and depth-first search*
2.9.2. *Implementation methods of BFS (with queue or without)*
2.9.3. *Connectivity test*
2.9.4. *Shortest path problem in weighed graphs*
2.9.5. *Topological sort, strong connectivity and order diagram* *
2.9.6. *Negative cycles – criterion, search algorithm* *
2.9.7. *Time synchronization and linear inequality system* *
2.9.8. *Eulerian cycle search (incl. lexicographically minimal)* *
2.9.9. *Transitive closure* *
2.9.10. *Weighted minimal spanning trees* *
2.9.11. *Search for 2-connectivity components, bridges and articulation points using DFS* *
2.9.12. *Bipartite matching and minimum vertex cover search* *
2.9.13. *Searching for maximal flow* **
2.9.14. *Searching for maximal flow of minimum cost* **
2.9.15. *Assignment problem – Hungarian method. Connection between Hungarian method, minimal-cost maximal-flow and Dijkstra algorithm* **
2.9.16. *Fast algorithms for maximal-flow problem:* $O(N^3)$ **

2.10. Dynamic programming

2.10.1. *The concept of dynamic programming. Recursive and linear implementation.*
2.10.2. *Monotone-direction problems*
2.10.3. *Backpack problem*

2.10.4. *Eliminating extra parameters **
2.10.5. *Building the way of solution using dynamic table **
2.10.6. *Common scheme of dynamic programming **
2.10.7. *Subset and profile dynamic programming **
2.10.8. *Broken-profile dynamic programming **

2.11. Game theory algorithms

2.11.1. *Dynamic programming and brute-force. DAG games **
2.11.2. *Retro-analysis. Effective implementation ***
2.11.3. *Fast Boolean evaluation. Using it in game analysis ***
2.11.4. *Position scoring. Alpha-beta pruning ***

2.12. Geometrical algorithms

2.12.1. *Test for coincidence of points, rays, lines and segments*
2.12.2. *Storing methods for points, lines and segments*
2.12.3. *Calculating distance between objects on the plane **
2.12.4. *Intersecting segments on the plane **
2.12.5. *Calculating polygon area using vertex coordinates. Pick's formula **
2.12.6. *Convex hull algorithms **
2.12.7. *Circles on the plane. Intersecting circles and other objects **
2.12.8. *Determining if the point is inside polygon **
2.12.9. *Scanning line method **
2.12.10. *Half-plane method ***
2.12.11. *Boundary detour method ***
2.12.12. *Effective algorithm of searching for two nearest points ***
2.12.13. *Effective algorithm for Voronoi diagram ***

3. Programming basics

3.1. Programming languages

3.1.1. *Types of languages*
3.1.2. *Procedure languages*
3.1.3. *Syntax and semantics of high-level languages*
3.1.4. *Formal syntax description methods: Backus–Naur form**
3.1.5. *Object oriented languages **

3.2. Programming constructions

3.2.1. *Variables, types, expressions and assignments*
3.2.2. *Input/output basics*
3.2.3. *Conditions and cycles*
3.2.4. *Functions and parameters*
3.2.5. *Structured decomposition **

3.3. Variables and data types

3.3.1. *Data types as set of values and operations*
3.3.2. *Declaration properties (linking, visibility area, blocks and lifetime)*
3.3.3. *Type matching*

3.4. Data structure types

3.4.1. *Primitives*
3.4.2. *Arrays*
3.4.3. *Record*
3.4.4. *Strategies of selection of appropriate data structure*
3.4.5. *Data storage in memory **
3.4.6. *Static, automatic and dynamic memory allocation **
3.4.7. *Pointers and references **
3.4.8. *Linked structures **
3.4.9. *Methods of implementing stacks, queues and hash tables **
3.4.10. *Methods of implementing graphs and trees **

3.5. Abstraction mechanisms

3.5.1. *Procedures, functions and iterators as abstraction mechanisms*
3.5.2. *Parameterization mechanisms (references and values)*
3.5.3. *Units in programming languages*
3.5.4. *Parameterized types ***

3.6. Fundamental programming species

3.6.1. *Task solving strategies*
3.6.2. *Role of algorithms in problem-solving process*
3.6.3. *Strategies of implementing algorithms*
3.6.4. *Implementing recursion*
3.6.5. *Testing strategies **

4. IT facilities

4.1. Digital logic

4.1.1. *Logical schemes*
4.1.2. *Scales of notation*
4.1.3. *Computer arithmetic*

4.2. Data representation

4.2.1. *Bits, bytes and words*
4.2.2. *Numeric representation **
4.2.3. *Fixed and floating point **
4.2.4. *Signed numbers representation **
4.2.5. *Non-numeric data representation, character codes, graphic data **
4.2.6. *Arrays and records **

4.3. Computer engineering principles

4.3.1. *Von Neumann principle*
4.3.2. *Control block: decoding and executing instructions*
4.3.3. *Instruction set and types (data manipulation, control, input/output)*
4.3.4. *Instruction formats **
4.3.5. *Addressing methods **
4.3.6. *Procedure calls and return **

4.3.7. *Input/output and interrupts **

4.4. Memory

4.4.1. *Operations with memory*
4.4.2. *Memory hierarchy*
4.4.3. *Data encoding, compression and integrity **
4.4.4. *Cache **

4.5. Communications

4.5.1. *I/O basics*
4.5.2. *External memory, external devices*
4.5.3. *Network technologies*
4.5.4. *DMA **

5. Operating systems

5.1. Operating systems basics

5.1.1. *Role and tasks of operating systems*
5.1.2. *Typical operating system functions*
5.1.3. *Directories: contents and structure*
5.1.4. *Naming, search, access, backup*

5.2. Basic functions of operating systems

5.2.1. *Abstractions, processes and resources*
5.2.2. *Device organization*
5.2.3. *Protection, access and authentication*

5.3. Memory control

5.3.1. *Physical memory and memory-controlling hardware*
5.3.2. *Segment and paged memory model. Flat model **
5.3.3. *Caching **

6. Basics of programming technologies

6.1. Programming facilities and space

6.1.1. *Programming space*
6.1.2. *Testing facilities **

6.2. Software quality assurance

6.2.1. *Basics of testing, testing plan **
6.2.2. *White box and black box methods **
6.2.3. *Integrated testing, element testing, system testing, quality assurance **
6.2.4. *Stress-testing **

7. Calculation methods and modeling

7.1. Basics of computational mathematics

7.1.1. *Basic methods of computational mathematics*

- *Finding roots and values of function **
- *Finding perimeter, area and volume **

7.1.2. *Grid and step methods **
7.1.3. *Floating point arithmetic ***
7.1.4. *Precision loss, stability, convergence ***

7.2. Modeling basics

7.2.1. *Concepts of model and modeling*
7.2.2. *Basic model types*
7.2.3. *Components of computer model and description methods: input and output variables, state variables, entry/exit functions, time shift*
7.2.4. *Stages and specials of building computer model*
7.2.5. *Basic stages of using computer models during solving problems*

8. Network technologies

8.1. Networks and communications

8.1.1. *Network cards and network devices*
8.1.2. *Data transfer media*
8.1.3. *Network architecture*
8.1.4. *Passwords and access control mechanisms*
8.1.5. *Service quality: performances, restoring after fault**

8.2. Wireless networks

8.2.1. *Specific problems of wireless and mobile computing*
8.2.2. *Installing programs on wireless and mobile computers*
8.2.3. *Wireless networks and links*

It is necessary to notice, that for the preparation of informatics teachers and coaches for informatics olympiads when using the described curriculum it is necessary to consider, that studying is presented in topics and didactic units should be going from simple to difficult. In particular, at first it is necessary to master the first level of complexity, and then to go further. Moreover, if teachers or coaches do not put before themselves the task of preparation of students for a successful performance at final stage of the Russian Olympiad in Informatics or the IOI it is enough for such teachers or coaches to master only the first level of complexity. It is important as such informatics teachers or coaches should have more knowledge even if they only teach to the first level, but not all of them can be in a condition to master higher level of complexity.

Only the most prepared teachers and coaches can be promoted to the third level of complexity. Here it is important to remember what evaluation of level of any informatics teacher-coaches preparation can be done by means of their pupils' achievements at informatics olympiads. If pupils get medals at the IOI then their informatics teacher-coaches will make gold fund of coaches of the country which will be capable to prepare students for victories on the national and international informatics olympiads.

6. Conclusion

Preparation of teachers according to the allocated levels of ICT competence plays the important role in development of informatization of each country. The curriculums of

preparation of teachers offered in this paper are applicable in other countries where the course of informatics and ICT (computer science) is included in the national education program on informatics and the national informatics olympiads are organized. Russian experience in this area can also be useful for the systematization of programs of school teachers preparation on informatics and ICT in any country. The problem of improving of ICT competence of teachers should be solved in a complex that will guarantee not only high level of studying of informatics at comprehensive schools, but also successes of students at the IOI.

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