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Foreword

International Olympiad in Informatics, or the IOI as it is often called, runs IOI conference jointly. The conference celebrates its tenth year anniversary and provides an additional volume of papers with a focus on experience and methodological ideas of informatics education from Russia, the host country of IOI this year. Kazan is home for the 28th Russian Olympiad in Informatics and the 28th International Olympiad in Informatics in 2016!

Soviet Union has had a long history of teaching Informatics at schools starting from early 1985. Two years later, in 1987, the Ministry of Education took the decision to start a Russian Olympiad in Informatics for all secondary school students. One year later, the first Russian Olympiad in Informatics took place in Sverdlovsk, now renamed as Yekaterinburg. A chairman was one of the best-known computer scientists of the world Andrei Ershov, notable as a pioneer in systems programming and programming language research (see more about A. Ershow on the website: http://ershov.iis.nsk.su/english). A. Ershow started to call programming as “the second literacy”. Fully aware of the social consequences of the ability to use computers, and of the cultural importance of programming, A. Ershov was a tireless forerunner of school informatics and took care introduction of computers and information technologies into pre-university education. He himself wrote (and co-authored) school curricula and textbooks, sponsored computer holiday camps for children, hosted an educational-TV series on Informatics, lectured on the dangers of computer illiteracy to the public, etc.

Now Informatics is well-established subject at school education in Russia: at primary level – grades 3 and 4, at secondary level – schools can choose either grades 5–9 or grades 7–9, and high school – grades 10 and 11. In a high school, Informatics is taught either as as one of the basic subjects or as a special training course (students have the possibility to choose one of the options). Additionally, each student in Russia can choose elective courses in information technologies (IT) either at school or in an open-class format, which supports Olympiad informatics as well. It is not surprising that Informatics is a part of school education in the 21st century. It is very important, that each child in Russia could study Informatics in every school.

In the last 10 years, IT education structure has been significantly improved in Russia. Close collaboration between innovative universities and schools are established – special Mathematics lyceums and IT-schools for talented students with a focus on studies in Informatics, Mathematics and IT are examples of the partnership. A brilliant example in the Republic of Tatarstan of such collaboration is a “digital bridge” of IT education on the campus of one of the oldest universities in Russia – the Kazan Federal University and its IT-lyceum.

Tatarstan is an outstanding innovative educational IT cluster in Russia. Kazan is a city with its famous area of IT education – an Innopolis city. Innopolis has modern IT infrastructure, including an IT school, an IT university (with bachelor, master, and doctoral programs) and a career centre in IT. This is a new educational model and forms so called “IT city”.

The special volume of the “Olympiads in Informatics” presents a modern school curriculum of Informatics in Russia. The current model of IT education “School-University” and “IT-city” Innopolis in Kazan, Tatarstan are discussed as well. Finally, a short overview of a challenge on informatics and computational thinking run by Sankt-Petersburg State university is presented.

A strategy of the Russian government has proposed a long-term plan for training highly qualified IT specialists and development of the IT sector. IT is the basis for an innovative economic cluster. IT can support each new high technology in space, energy, automated production, medicine, ecology, and many more.

Many thanks to the Editorial Board of the IOI journal “Olympiads in Informatics” and to all who had assisted with the special volume – especially authors, reviewers and editorial board. A lot of work is required there by starting from writing papers until finishing their final collection for the volume. Last, but by no means least, particular thanks are due to the Organisational Committee for IOI’2016 in Russia without whose assistance we would be unable to hold the conference and this Special Issue of the IOI journal.

Guest Editor Prof. Marina S. Tsvetkova

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Informatics at Russian Primary School

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Abstract. The expedient and wide use of IT and the possibilities of modern educational information materials in the context of the intensification of information processes in society and education. Teaching younger students to use IT well is one of the important ways of developing academic activity and independence. Informatics as an academic subject at primary school is the main means of developing younger students' capacity for algorithmic thinking.

Keywords: **i**nformatics, primary school, skills younger school students on informatics, IT literacy.

1. Introduction

The Informatics as a subject is included at the Russian schools in the 90th years of the 20th century. Everywhere in the country, it has begun to be studied by younger school students (two or three years of studying) since 2005. Since 2012 informatics at primary school is included in the cluster of mathematical subjects. Before it was considered as a subject in the cluster of technological subjects of school.

Since 2009 in the new Russian school educational standard (Minobrnauki of Russia, 2009) in which not only studying in informatics is provided in a cluster of mathematical subjects (algorithmic thinking), but also the special program of IT teaching of children (IT literacy) in integration with other school subjects is entered. The informatics as a subject has two sections of contents – algorithmic and technological. The informatics course at school sets invariant requirements to competences of pupils, but the school can choose model of realization of a course taking into account resource providing. The number of Informatics lessons cannot be less than 70 hours for a course in primary school.

The planned results of learning of younger school students on informatics are given below: topics and number of lessons. Skills of pupils on each topic are specified.

2. Topic: Getting Acquainted with ICT Equipment and Computer Hygiene (6 Lessons)

Students will learn:

- To use computers and other ICT facilities ergonomically in a way which does not endanger their organs of sight, nervous system or musculoskeletal system; perform desk exercises to compensate for a lack of physical movement.
- To organise a filing system for storing their own information on a computer.

3. Topic: The Technology of Inputting Information onto a Computer: Inputting Text, Recording Sounds, Images and Numerical Data (10 Lessons)

Students will learn:

- To master textual input using a keyboard.
- To input information into a computer using different technologies (photo- and video-cameras, microphones, etc.), and save the information obtained.
- To select short texts in their native language; to select short texts in a foreign language and use machine translation for separate words.
- To draw (create simple images) on a graphics tablet.

Students will have the opportunity to learn:

- *To scan in drawings and texts.*
- *To use text recognition software for scanned text in Russian.*

4. Topic: Information Processing and Searches (18 Lessons)

Students will learn:

- To select a video or photo result suitable regarding content and technical quality, and use removable storage media (flash drives).
- To describe an object or observation according to a specific algorithm, and record audiovisual and numerical information about it using ICT tools.
- To compile numerical data from natural science observations and experiments using digital sensors, cameras, microphones and other technical items, and also from surveys of people.
- To edit texts, graphic images, slides in conjunction with communications or academic tasks, including textual editing, image chains, video and audio files and photo images.
- To use the main functions of a standard textual editor, and use a semiautomatic spellchecker; to use, add and remove links in messages of different types; to follow the basic rules of formatting a text.
- To search for information in age-appropriate digital dictionaries and manuals, in

databases, on controlled internet, in the computer's internal search system; to compile a list of information sources used (including link usage).
- To populate a study database.

Students will have the chance to learn:

- *How to accurately formulate queries when searching the internet and databases, and evaluate, interpret and save information which they find.*
- *To critically assess information and choice of information sources.*

5. Topic: Creating, Submitting and Sending Messages (18 Lessons)

Students will learn:

- To create text messages using ICT, and edit, format and save them.
- To create simple messages in the form of audio and video fragments or slide sequences using illustrations, video images, sounds and text.
- To prepare and give a presentation in front of a small audience: to create a presentation plan, select audiovisual support, write explanations and arguments for the presentation.
- To create schemes, plans, diagrams, etc.
- To create simple images using the graphic capabilities of a computer; to compile new images from ready-prepared fragments (application).
- To place a message in the educational information environment of an educational organisation.
- To use basic means of telecommunication; to take part in collective communication activities in an educational information environment, and to record the path and result of the communication on-screen and in files.

Students will have the opportunity to learn:

- *How to present data.*
- *To create musical compositions using a computer and a music keyboard, including from ready-prepared musical fragments and music loops.*

6. Topic: Planning Activity, Management and Organisation (18 Lessons)

Students will learn:

- To determine a sequence of completing actions, compile instructions (simple algorithms) for certain activities, build programs for a computer executor using sequence or repeat constructs.
- To create moveable models and control them using a computer (to create simple robots).
- To plan simple research of objects and processes in the outside world.

Students will have the opportunity to learn:

- *To project simple real-world objects and processes, their own activity and the activity of the group, including robotics projecting skills.*
- *To model real-world objects and processes.*

7. Conclusion

Within 25 years of development of school informatics in Russia techniques of early learning of children in informatics were created. Now at each school of Russia informatics lessons at primary school are led. It helps early identification of talented children on informatics and their inclusion in Olympiad preparation.

The informatics course at primary school is added with electronic training materials on the website `http://www.sc-edu.ru`, interactive electronic notebooks and textbooks (for example, `http://metodist.lbz.ru/authors/informatika/5/`), manuals on informatics course (for example, `http://metodist.lbz.ru/authors/informatika/5/umk3-4.php`).

The presented contents of a course of informatics at an elementary school are realized in programs of learning (Kuris and Tsvetkova, 2013) and textbooks for them which have passed the examination of the Ministry of Education and Science of Russia.

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Competencies of Graduates of High School for State Exam (K-11) Informatics in Russia

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Abstract. The article presents Codifier elements of the content and competencies of graduates of high school for unified state exam Informatics.

Keywords: informatics, computer science, curriculum in informatics at high school (K-11).

1. Introduction

The State Exam in Informatics is an exam of choice for high school graduates in Russia (it started in 2008).

Those students who chose a university with an IT profile take the test and its results are taken into account for admission to the university with status of a state exam in mathematics and Russian language.

To prepare for the exam in computer science high school students learn Informatics at the advanced level from 2 to 4 hours per week (a total of 280 hours at 10–11 classes)

The Informatics course includes mathematical foundations of computer science, IT tools and social aspects of information culture.

The exam includes questions on these topics, as well as tasks for the development of algorithms and programming. The examination is conducted in a test form using a computer.

Each version of the examination paper consists of two parts and includes 27 tasks, different forms and levels of complexity. The exam takes a total of 3 hours 55 minutes (FIPI, 2016a).

Part 1 contains a 23 job base, with increased and high levels of difficulty. This part contains a brief reference answer – or in the form of symbol sequence. The test checks all material topics. Part 1: 12 jobs related to baseline for 10 jobs an increased level of complexity, one task – to a high level of complexity. Part 2 contains 4 tasks with detailed answer (FIPI, 2016b).

2. Topics of the State Exam in Informatics

1. Information and Information Processes:

   1.1. Information and its Coding:

   - Types of information processes.
   - The process of transmission of information, the source and the receiver information. Signal encoding and decoding. garbled information.
   - Discrete (digital) representation of text, graphics, audio and video information. Units of measurement of the amount of information.
   - The speed of information transfer.

   1.2. Systems, components, condition and interaction of the components. Information interaction in the system, management, feedback.

   1.3. Modeling:

   - Description (information model) and the real object of the process, matching the description of the object and the goals. Diagrams, tables, graphs, formulas as descriptions.
   - Mathematical models.
   - The use of simulation environments (virtual laboratories) for the computer experiment in educational activity.

   1.4. Number Systems:

   - Positional number system.
   - Binary representation of information.

   1.5. Logic and algorithms:

   - Statements, logical operations, quantifiers, the truth of the statements.
   - Chains (finite sequences), trees, lists, graphs, matrices (arrays), pseudo-random sequence.
   - Inductive definition objects.
   - Computable functions completeness of formalizing the notion of computability, universal computable function.
   - Coding.
   - Sorting.

   1.6. Elements of the theory of algorithms:

   - The formalization of the concept of algorithm.
   - Computability. The equivalence of algorithmic models.
   - Construction of algorithms and practical computations.

   1.7. Programming Languages:

   - Data Types.
   - programming language syntax. programming system.
   - The main stages of program development. Breaking tasks into subtasks.

2. Information Activities:
   - 2.1. Professional information activities. Informational resources.
   - 2.2. Economics of the information sphere.
   - 2.3. Information ethics and law, information security.
3. ICT Tools:
   - 3.1. Architecture of computers and computer networks:
     - Software and hardware organization of computers and computer systems. Types of Software.
     - Operating Systems. The concept of system administration.
     - Safety, hygiene, ergonomics, resource, technological requirements when operating a computer workstation.
   - 3.2. Technologies of creation and processing of textual information:
     - The concept of desktop publishing. Creation of computer publications.
     - The use of ready-made templates and create your own. Using systems of spelling and grammar. Thesaurus. The use of bilingual translation and electronic dictionaries.
     - The use of specialized editing tools of mathematical texts and the graphical representation of mathematical objects.
     - The use of OCR systems.
   - 3.3. The creation and processing of graphics and multimedia technology:
     - Formats of graphical and sound objects.
     - Entering and processing of graphics.
     - Entering and processing of audio objects.
   - 3.4. Processing of numerical information:
     - The mathematical processing of statistical data.
     - Using dynamic (e) tables to perform learning tasks.
     - Using tools and solutions statistical calculation and graphic tasks.
   - 3.5. Search technology and information storage:
     - Database Management Systems. Database Organization.
     - Using tools search engines (querying).
   - 3.6. Telecommunication technologies:
     - Special software tools telecommunication technologies.
     - Tools create data objects for the Internet.
   - 3.7. Control technology, planning and organization.

3. Competences

3.1. *Know / Uunderstand / Do*

Simulate objects, systems and processes:

- Calculated in table systems.
- To represent and analyze the information in the tables in the form of charts and graphs.
- Building information models of objects, systems and processes in the form of algorithms.
- Read and debug programs in a programming language.
- Create programs of a description.
- Build models of objects, systems and processes in the form of a truth table for the logical statements.
- Calculate the value of the complex logical statements from the known values of the elementary statements.

Skills in algorithmic problems:

- Finding a minimum and a maximum of two, three, four numbers of data without the use of arrays and loops.
- Finding all the roots of a given quadratic equation.
- Entry of positive integer positional system with base less than or equal to 10. The processing and conversion of such a record.
- Finding sums of products of elements of the final numerical sequence (or array).
- The use of cycle for simple search problems (finding the smallest prime divisor of natural numbers, check numbers on simplicity, etc.).
- Filling elements dimensional and two-dimensional arrays on pre-defined rules.
- Operations of the array elements. Linear searching for the item. Insertion and removal of elements in the array. Rearrange the elements of the array in reverse order. The summation of elements in the array. Checking the array elements selected conditions.
- Being the second largest (second maximum or minimum) values in the array for a single view of the array.
- Finding the minimum (maximum) values in the array and the number of elements equal to him for a single view of the array.
- Operation with an array of elements, selected according to a certain condition (for example, finding even a minimum element in the array to find the number and amount of all even elements in the array).
- Sorting an array.
- Merging two ordered arrays into one without sorting.
- Processing of the individual characters of the string. Counting the frequency of occurrence in the character string.
- Working with the substring of this string with the division into words at whitespace. Finding a substring within a given string, the replacement substring with another string.

Interpret the results of modeling:

- Use a ready-made model to assess their compliance with the real object and goals of modeling.
- Interpret results obtained during the actual process modeling.

Evaluate the numerical parameters of information objects and processes:

- Assess the amount of memory required to store information.
- Evaluate the baud rate and data processing.

3.2. *USE Skills in Practice and Everyday Life*

- To carry out the search and selection of information.
- Create and use a data storage structure.
- Work with common automated information systems.
- Prepare and conduct presentations, engage in collective discussion, to fix its course and results of the use of modern software and hardware communications.
- To carry out the statistical processing of the data using a computer.
- To carry out the safety requirements of hygiene, ergonomics and resources when dealing with informatization means.

Performing each task in Part 1 is estimated at 1 point. The task of Part 1 is met if the examinee has answered matching the correct answer. For each task is assigned (in a dichotomous system evaluation), 0 points ("Target"), or 1 point ("task done"). Replies to paragraph 1 are automatically processed after scanning of forms of answers.

The maximum number of initial points is 23 in part 1.

Completing quests in Part 2 scores from 0 to 4 points. Answers to the tasks in part 2 are tested and evaluated by experts. The maximum number of points is 12 in part 2.

The maximum score for the test is 35.

Points for admission to universities are counted on a 100-point scale, which is based on the analysis of the results of the exam performance in Russia this year and recorded in the certificate of high school graduates.

In 2015, the state exam Informatics passed more than 50 thousand high school graduates. On a scale of 100, they showed an average score of 53,6 (Mathematics – 45,4 and Physics – 51,2).

4. Conclusion

The winners of the final stage of the All-Russian Olympiad, members of the Russian national teams participating in the International Science Olympiad, at university on a specialty on the profile of the subject of the international competitions, are accepted without entrance examinations. (EGE, 2016).

The regional stage of the Olympiad was attended by more than 4 thousand students (8–11 classes) from 80 regions of Russia. About 100 participants of these (winners of the final stage) annually receive the right to enter the university without examination.

They are all winners a cash prize of the Russian Government and the Grand – a monthly student scholarship of the President of Russia for the period of study at the university.

The participation of the winners of the Olympic Games in training camp (winter and summer) and a trip to the International Olympiad in Informatics is fully paid by the Russian Government.

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Informatics at Russian Secondary School

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Abstract. "Informatics" as an academic subject imparts a culture of information science and algorithms on a student; the ability to format and structure information, knowledge and experience using a variety of methods of data representation in relation to a particular task (lists, graphs, arrays, tables, schemes, graphics, diagrams and hierarchical structures) and using relevant programs of data processing; the idea of a computer as a universal information-processing device; the idea of basic concepts which they study: information, algorithms, models, and their properties. It develops algorithmic thinking necessary for professional activity in modern society; explains how concepts and constructs of informatics are applied in the real world, about the role of information technology and automated devices in people's lives, as well as in industry and scientific research; skills and abilities for safe and appropriate use of computers and internet networks, and the ability to observe the norms of communication, and operate ethically and within the law.

Keywords: informatics, computer science, curriculum in informatics at secondary school.

1. Introduction

In Russian schools, informatics as a subject has been included in the secondary and high schools since 1985 (Ershov *et al.*, 1985). The first version of the subject was developed at the initiative of Academy of Sciences of the country. Since 1998 the first standard on informatics according to which all pupils of the country studied informatics from 8 to 11 grades as a separate subject has been introduced.

In 2010–2012 the new school educational standard for secondary and high schools (Minobrnauki of Russia, 2010) was developed in Russia. In this standard there is not only studying of informatics from 5 to 9 grades at the secondary school and at 10–11 classes of high school, but also a special program of IT studying of children is provided (a task – formation of IT of literacy) and design activity by pupils in integration with other school subjects (metasubject results of training).

The textbooks on informatics for the secondary school join the content of studying which carries out both tasks. These subjects are invariant for schools, but the school can develop them and supplement (further it is italicized). To each subject the quantity of lessons (not less than 70 for a course) and the approximate content of studying is specified. An important place is allocated to an algorithmic component of contents that is very useful for olympiad training of talented school students already from the 5th grade.

2. Secondary School Informatics Curriculum

The text shows possible study topics for students in the 5th–6th grade (1 hour a week, totalling 70 hours) and in the 7th–9th grade (1 hour a week, totalling 105 hours in the course). If a student continues the subject from the 5th to 9th grade, they will study a total of 180 hours. *Supplementary course material not subject to assessment is indicated by italics.*

3. Topic "Informatics and Information Processes"

Section "**Introduction**"

- 5th–6th grade (2 hours)

  Information is one of the main general concepts in modern science.

  There are different elements to the word "information": information in the form of data, which can be processed by an automated system, and information in the form of knowledge intended for human interpretation.

  Types of information and data: texts, numbers, graphics and sound.

- 7th–9th grade (4 hours)

  The history of the development of informatics as a science, and the work of Russian scientists. The concept of cybernetics. The ability to describe continuous objects and processes using discrete mathematics.

  Information processes – processes connected with storage, conversion and transfer of data. Examples of information processes in technical and social areas, and in nature.

Section "**The computer as a universal data-processing device**"

- 5th–6th grade (2 hours)

  Variety of computers. Information carriers used in ICT. Historical and future developments.

  Hygiene, ergonomics and technical conditions of using ICT equipment.

- 7th–9th grade (4 hours)

  Computer architecture: processor, RAM, external NVRAM, input/output devices; their specifications.

Computers embedded in technical devices and production complexes. The robotising of production, additive technologies (3D-printers).

Software and hardware in a computer's operation.

Data volumes and access speeds characteristic of different types of carriers. *Information carriers in nature*.

Safety techniques and rules of computer use.

Economic, legal and ethical aspects of ICT use.

History and trends in computer development, improving computer characteristics. *Supercomputers*.

Physical limitations on computer characteristics.

Parallel computing.

4. Topic "The Mathematical Basis of Informatics"

Section "**Coding**" (2 hours)

- 7th–9th grade

  Symbols. The alphabet is a finite quantity of symbols. Text is a finite sequence of symbols in a given alphabet. The quantity of different texts of a certain length in a certain alphabet.

  Variety of languages and alphabets. Natural and formal languages.

  Coding symbols of one alphabet using code words in another alphabet; code tables, decoding.

Section "**Numeral systems**"

- 5th–6th grade (2 hours)

  Positional and non-positional numeral systems. Examples of representing numbers in positional numeral systems. Octal and hexadecimal numeral systems. Converting natural numbers from the decimal system to octal and hexadecimal systems and back again.

- 7th–9th grade (4 hours)

  The base of a numeral system. The alphabet (plurality of digits) of a numeral system. Quantity of digits used in a numeral system with a particular base. Short and long forms of written numbers in positional numeral systems.

  The binary numeral system, writing whole numbers within the range of 0 to 1024. Converting natural numbers from the decimal system to binary and binary to decimal.

  Converting natural numbers from the binary system to the octal and hexadecimal system and back again.

  Arithmetic in numeral systems.

Section "**The binary alphabet**" (4 hours)

- 7th–9th grade

The representation of data in a computer as texts in a binary alphabet.

Binary code with a fixed codeword length. Code width – length of codeword. Examples of binary code with widths of 8, 16, 32.

Units of measurement for binary text length: bit, byte, kilobyte, etc. The quantity of information contained in a message.

Kolmogorov's approach to determining the quantity of information.

The dependence of the quantity of combinations of code on code width. *ASCII code*. Coding the Cyrillic alphabet. Examples of coding letters in national alphabets. Standard Unicode. *Code tables with an alphabet other than binary.*

Distortion of code during transfer. Error-correcting codes. The capability of unique decoding for codes of various codeword length.

Section "**Discretising**" (3 hours)

- 7^{th}–9^{th} grade

  Measurement and discretising. General digital representations of audiovisual and other continuous data.

  Coding colours. Colour models. RGB and CMYK models. *HSB and CMY models*. Depth of coding. Acquaintance with raster and vector graphics.

  Coding sound. Width and frequency of a recording. Quantity of recording channels.

  Evaluating quantitative parameters connected with representation and storage of image and sound files.

Section "**Elements of combinatorics, set theory and mathematical logic**"

- 5^{th}–6^{th} grade (6 hours)

  Sets. Specific quantities of elements in sets obtained from two or three base sets using union, intersection and addition operations.

  Expressions. Simple and complex expressions. Euler-Venn diagrams. Logical values of expressions. Logical expressions. Logical operations: "and" (conjunction, logical multiplication), "or" (disjunction, logical addition), "is not" (logical negation).

- 7^{th}–9^{th} grade (6 hours)

  Calculating the quantity of variants: formulae for multiplication and addition of variant quantity. Quantity of texts of a given length in a given alphabet.

  Logical expressions. Rules of recording logical expressions. Logical operation priorities.

  Truth tables. Building truth tables for logical expressions.

  Logical sequential operations (material conditional) and logical equality operations. Properties of logical operations. Laws of algebraic logic. Use of truth tables to prove laws of algebraic logic.

  Acquaintance with the logic foundations of a computer. The cell base of a computer. The history of cell bases. Logic cell circuits and their physical (electronic) realisation.

Section "**Lists, graphs and trees**" (6 hours)

- 7th–9th grade

Lists. First element, final element, previous element, next element. Insertion, deletion and substitution of elements.

Graphs. Vertices, edges and paths. Directed and undirected graphs. The initial vertex (source) and final vertex (terminal) in a directed graph. Length (weight) of an edge and path. The concept of shortest path. Adjacency matrices of a graph (with edge lengths).

Trees. Roots, leaves and vertices (nodes). Earlier vertex, later vertex. Subtrees. Peripherals. *Binary trees. Genealogical trees.*

Section "**Executors and algorithms. Executor control**"

- 5th–6th grade (7 hours)

States, possible circumstances and system of executive commands; order commands and enquiry commands; executor refusal. The need formally to describe an executor. Manual executor control.

Executor control algorithms. A computer is an automatic device able to control executors to carry out commands according to a previously-assembled program. Computer control of an executor.

Computer control of a self-propelled robot. Compiling algorithms and programs to control an executor on a computer (robot, turtle etc.).

- 7th–9th grade (3 hours)

Signals. Feedback. Examples: a computer and an executor under their control (including a robot); a computer receiving a signal from a digital sensor during observations and experiments and controlling actual (including moving) devices.

Examples of robotised systems (a system controlling movement in a transport system, a welding line in a car factory, an automated home heating system, an autonomous transport control system etc.).

Section "**Robotics**"

- 5th–6th grade (15 hours)

Robotics is the science of developing and using automated technical systems. Autonomous robots and automated complexes. Microcontrollers. Signals. Feedback: receiving signals from digital sensors (touch, range, light, noise etc.).

Autonomous moving robots. Executor devices and sensors. Robot command system. Robot design. Robot modelling: command executor and control device. Manual and computer control of robots.

Example of a learning environment for developing control programs for moving robots. Control algorithms for moving robots. Realisation of "obstacle- avoidance", "follow-the-line" and other algorithms.

Analysis of robot-activity algorithms. Robot mechanism testing, debugging of robot-control program. Impact of measurement and calculation mistakes on the fulfilment of robot-control algorithms.

5. Topic "Algorithms and Elements of Programming"

Section "**Algorithms**"

- 5th–6th grade (12 hours)

  Verbal description of algorithms. Describing algorithms using flowcharts. Distinguishing verbal descriptions of algorithms from descriptions in formal algorithmic language.

  Algorithmic constructs.

  Sequence constructs. Linear algorithms. Limitations of linear algorithms: the inability to foresee the dependence of a sequence of actions to be fulfilled on source data.

  Selection constructs. Conditional operator: full and non-full forms.

  Fulfilment and non-fulfilments of a condition (true and false expressions). Simple and compound conditions. Compound condition recording.

  Repeat constructs: cycles with a set number of repetitions, with a condition for fulfilment, with a cycle variable. *Checking of fulfilment conditions of a cycle before and after the cycle body: post- and preconditions of the cycle. Cycle invariants.*

  Recording algorithmic constructs in a selected programming language.

- 7th–9th grade (12 hours)

  An algorithmic language (programming language) is a formal language for writing algorithms. A program is an algorithm written in a specific algorithmic language.

  Examples of written commands of selection, repeat and other constructs in different algorithmic languages.

  Programming systems. Means of creating and executing a program.

Section "**Development of algorithms and programs**" (18 hours)

- 7th–9th grade

  Concepts of a program's development stages: compiling a program's requirements, selecting an algorithm and realising it in the form of a program in a chosen algorithmic language, debugging the program using a chosen programming system, and testing.

  The simplest techniques of dialogue debugging programs (selecting a breakpoint, executing it step-by-step, revising the values of the variables, post-mortem debugging).

  Acquaintance with program documentation. *Compiling descriptions of programs by sample.*

  Examples of program development.

  Operators.

  Representations of data structures.

  Constants and variables. Variable: name and value. Types of variables: integer, real, symbolic, string, and logic. Tabular values (arrays). Single-dimensional arrays. *Two-dimensional arrays*.

Subprograms.

Examples of data processing problems:

- Identifying the smallest and largest number from two, three or four supplied numbers.
- Identifying all roots of a quadratic equation.
- Populating a number array in relation to a formula or numerical input path.
- Identifying the sum of elements in a given finite number sequence or array.
- Identifying the smallest (largest) element in an array.

Acquaintance with algorithms to solve these tasks. Realising these algorithms in a chosen programming environment.

Acquaintance with arrangements of more complex data-processing problems and the algorithms of their solutions: array sorting, element-wise operations with arrays; processing of integers represented in decimal and binary numeric systems, identifying the largest common denominator (Euclid's algorithm) etc.

Section "**Analysis of algorithms**" (2 hours)

- 7th–9th grade

Complexity of an algorithm: time to execute the program and number of operations performed, memory usage; reliance on the size of source data. Examples of short programs process a small volume of data over many steps; examples of short programs processing a large volume of data.

Determining possible algorithm results in a given set of input data; determining possible input data leading to this result. Examples of describing objects and processes using a selection of digital characteristics, as well as interdependencies of said characteristics expressed by means of a formula.

Section "**Mathematical modelling**"

- 5th–6th grade (5 hours)

Concept of mathematical models.

Problems solved using mathematical (computer) modelling. Distinguishing mathematical models from full-scale models and verbal (literal) descriptions of objects.

- 7th–9th grade (5 hours)

Using computers while working with mathematical models. Computer experiments.

Examples of mathematical (computer) model usage when solving technical problems. Representation of a modelling cycle: building a mathematical model, its realisation on a computer, simple example checking (testing), carrying out computer experiments, analysing the results, refining models.

6. Topic "Using Computer Programs and Services"

Section "**File system**"

- 5^{th}–6^{th} grade (2 hours)

  Principles of building file systems. Catalogues (directories). Fundamental operations for working with files: creating, editing, copying, moving, deleting. Types of files.

- 7^{th}–9^{th} grade (3 hours)

  Typical sizes of different types of files: a page of text, a whole book, a minute-long video, a one-and-a-half-hour film, a file of astronomical observations data, a temporary information file when mathematically modelling complex physical processes, etc.

  File manager.

  File system search.

  Archiving and dearchiving.

  Overview of programs. Data compression concepts. Work with archivers.

Section "**Preparing texts**"

- 5^{th}–6^{th} grade (6 hours)

  Text documents and their structural elements (page, paragraph, line, word, character).

  Methods of textual input using a scanner, textual recognition software, speech recognition software. Machine translation.

  Spellcheckers and dictionaries.

- 7^{th}–9^{th} grade (6 hours)

  Word processor – an instrument for creating, editing and formatting texts. The properties of a page, paragraph, character. Style formatting.

  Including lists, tables and graphics in a text document. Including diagrams, formulae, page numbers, headers and footers, links etc. in a text document. *Track changes*.

  The concept of a system of information, library and publishing standards. Business correspondence, academic publications, collaborative work. Abstract and footnotes.

Section "**Computer presentation**"

- 5^{th}–6^{th} grade (4 hours)

  Preparing computer presentations.

- 7^{th}–9^{th} grade (3 hours)

  Including audiovisual objects in the presentation. Using templates. Display controls of a presentation.

Section "**Graphic editing**"

- 5^{th}–6^{th} grade (4 hours)

Acquaintance with graphic editing.

Inserting images using different digital devices (digital cameras and microscopes, video-cameras, scanners etc.).

- 7^{th}–9^{th} grade (4 hours)

Raster and vector graphics.

Editing graphic objects: altering size, compressing an image, cropping, rotating, inverting, working with particular areas (highlight, copy and fill colour), altering colour, brightness and contrast. *Acquaintance with photo processing. Geometrical and stylistic transformations.*

Means of computer projecting. Blueprints and working to them. Base operations: highlighting, joining, geometrical transformation of fragments and components. Diagrams, plans and maps.

Section "**Electronic (dynamic) tables**" (4 hours)

- 7^{th}–9^{th} grade

Electronic (dynamic) tables. Formulae using absolute, relative and mixed addressing; transforming formulae when copying. Highlighting table range and ordering (sorting) its elements; building graphs and diagrams.

Section "**Databases. Managing requests**" (3 hours)

- 7^{th}–9^{th} grade

Databases. A table as a representation of relationships. Building a data search request in a ready-prepared database. *Links between tables*.

Section "**Work in the information space. Information and communication technologies**"

- 5^{th}–6^{th} grade (3 hours)

Computer networks. The internet. Internet addresses. Domain name system. Websites.

Types of internet network activity. Internet services: e-mail, reference services (maps, planners etc.), search engines, software update services etc.

- 7^{th}–9^{th} grade (6 hours)

Means and methods of information searches. Constructing enquiries; browsers. Computer encyclopaedias and dictionaries. Computer maps and other reference systems.

Network data storage. *More data in nature and technology (genomic data, results of physical experiments, internet data, in particular data on social networking sites). Technologies of processing and storing it.*

Techniques to improve internet safety. Computer viruses and other malware; defending against them.

Problems of authenticating obtained information. Electronic signatures, certified sites and documents. Methods of individual and collective packaging of information on the internet. Interaction on computer networks: e-mail, chat, forums, teleconferences etc.

Social communication on the internet. Personal information, and means of protecting it. Organisation of personal information space on a network.

Basic trends in the future development of ICT.

Standards in the field of informatics and ICT. *Standardisation and standards in the field of informatics and ICT before the computer age (numerals, alphabets of national languages etc.) and in the computer age (programming language, addressing, internet networks etc.)*

7. Conclusion

Informatics as an academic subject imparts a culture of information science and algorithms on a student; the ability to format and structure information, knowledge and experience using a variety of methods of data representation in relation to a particular task (lists, graphs, arrays, tables, schemes, graphics, diagrams and hierarchical structures) and using relevant programs of data processing; the idea of a computer as a universal information-processing device; the idea of basic concepts which they study: information, algorithms, models, and their properties; it develops algorithmic thinking necessary for professional activity in modern society; explains how concepts and constructs of informatics are applied in the real world, about the role of information technology and automated devices in people's lives, as well as in industry and scientific research; skills and abilities for safe and appropriate use of computers and internet networks, and the ability to observe the norms of communication, and operate ethically and within the law.

The subject's place is determined by academic results and reflected in personal, interdisciplinary and subject-specific results.

Personal results of mastering the basic educational programme of secondary general education should reflect the ability to engage in communication in social and collaborative processes of educational, socially-beneficial, academic-research, creative and other activities.

Interdisciplinary results of mastering the basic educational programme of secondary general education should reflect the formation and development of competence when using information and communication technologies (hereon "ICT capabilities").

The twofold inclusion of informatics into the school curriculum is reflected in the two vectors of academic performance:

- The development of algorithmic and logical thought processes and of mathematical models, including:
  - The creation of a culture of information science and algorithms.
  - The basic concepts studied: information, algorithms, models and their properties.
  - The development of algorithmic thinking seen as necessary for professional activity in modern society.

- The development of the ability to compile and write an algorithm for a specific operator.
- An understanding of algorithmic constructs, logical values and operations.
- A knowledge of one of the programming languages and fundamental algorithmic structures – linear, conditional and cyclic.
- The ability to format and structure information, select a method of data representation in relation to a particular task – tables, schemes, graphics or diagrams using relevant programs of data processing.
- The mastering of simple methods of presenting and analysing statistical data; the representation of statistical regularity in the real world and of various methods of their study, the depiction of the simplest probability models; the development of the ability to extract information represented in tables, diagrams and graphics, describing and analysing numerical data arrays using suitable statistical characteristics and using an understanding of the probability properties of environmental factors when making decisions.

- The representation of fundamental informational processes in real-life situations and on a computer:
  - The representation of a computer as a universal information-processing device.
  - The development of basic skills and abilities for using computer devices.
  - The development of abilities to apply the studied concepts, results and methods for solving practical tasks and tasks in related disciplines by using a computer.
  - The obtaining of skills and abilities for safe and appropriate use of computers and the internet, and the ability to observe the norms of communication, operate ethically and within the law.

The informatics course at secondary school is augmented with electronic training materials on the websites[1],[2], and also electronic textbooks and manuals on course[3],[4].

The course extends additional lessons according to the choice of school students, including on olympiad informatics (Kiryukhin and Tsvetkova, 2014). Content of preparation on olympiad informatics and the technique of such preparation has been presented earlier (Kiryukhin, 2007; Kiryukhin, 2010; Kiryukhin and Tsvetkova, 2011).

[1] `http://www.sc-edu.ru`
[2] `http://www.fcior.edu.ru`
[3] `http://metodist.lbz.ru/authors/informatika/1`
[4] `http://metodist.lbz.ru/authors/informatika/2`

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Preparing to Olympiads in Informatics in Tatarstan Republic, Russia. The Experience of Kazan Federal University

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Abstract. In the paper we describe the part of the history of Olympiads in informatics in the Tatarstan Republic, Russia which connected with the Kazan Federal University. It began in the 80s of XX century and now there are several centres of Olympiads in informatics in Tatarstan and one of them is the Kazan Federal University.

In the second part of the paper we describe the current approach to organize the lessons on informatics. The main idea is a seamless transition from "lessons 1.0"(teacher prepares all materials for students) to "lessons 2.0"(students prepare all materials for students), like the transition from Web 1.0 to Web 2.0.

Keywords: training activities, camps, national Olympiad in informatics, history.

1. Introduction

At the end of 60s students of high schools of Tatarstan had first lessons on Programming and Informatics. In the early 80s they began to study at Universities and work at companies using computers. In the middle 80s, there was a period when our schools got personal computers.

In 1985 teachers of Computational Mathematics and Cybernetics (CMC) department of Kazan State University (now it is Institute of Computational Mathematics and Information Technologies of Kazan Federal University) organized a first Olympiad in Informatics for Kazan high school students. There were about 40 students in the competition, and its jury chairman was assistant lecture of CMC department Ravil Hadiev. Additionally, in 1986 same staffs of the CMC department of KFU organize first camp in Informatics.

At the same time three factories (Kazan factory of Computers, Elecon and Kamaz with FORT “Dialog” company) began to produce personal computers. In 1987 FORT “Dialog” company suggested to organize the first regional Olympiads in Informatics for students of high schools in Brezhnev (Naberezhnye Chelny) city. And staffs of CMC department of KFU prepared problems for this contest. The winner of this competition was Ziganshin M., a student of one of Brezhnev city’s schools. All winners who graduated school that year entered Kazan State University (KFU) and helped to organize next regional Olympiads in Informatics in 1988. That year new winner was a Kuyanov Maxim student of the Kazan school no.131.

At the same time the first regional Olympiads for village schools of Tatarstan was organized and staffs and students of the CMC department of KFU also prepared problems and took part in organizing work.

Since 1990 The Ministry of Education of Tatatrstan has been organizing regional Olympiads in Informatics using own staffs.

The experience of this work was published in (Hadiev *et al.*, 1992) by Hadiev R.M., Anufriyeva A.I., Suleymanov D.Sh. In 1992.

Since 1989 training camps on programming and informatics have been organized. First of them was in Bolshiye Nirsi village, which was organized by staffs and students of the CMC department of KFU. Later using same ideas was organized other camps like “Selet” and “Baytik”. First “Selet” camps were organized by same staffs.

Since 2002 staffs of CMC department of KFU have worked with students of university and schools and prepare them for Olympiads on Informatics and contests like ACM ICPC.

2. An Organization of Training for Olympiads in Informatics and Programming Contests with Students in Center

Training process contains several points:

- Weekly theoretical classes.
- Weekly practical classes.
- Open contests, three in a year.
- Two exam contests in a year.
- Training camps.

Students have one theoretical and one practical lesson a week. Students of a school and students of university work together. This situation is useful for both groups of students. On the one hand, it is a competitive atmosphere for university students. They look at smart school students and try to be better. On the other hand, school students do not think that end of school is the end of Olympiads, they see many opportunities for students who interested in programming contests. As a result, school students taking part in contests during the last years of studying at school do not stop and continue to compete at the university. Smart school students look at smart university students that is why do not stop evolution (Hadiev and Khamizova, 2003).

We separate all pupils to five groups:

- Elementary group.
- Beginners group.
- Base group.
- Advanced group.
- Professional group.

Main parameter of separation is knowledge, but it is not study year.

2.1. *Weekly Lessons*

Each group had two lessons a week. One of them is theoretical and the second one is practical.

Theoretical lesson is not lecturing, it is a discussion about how to solve classical problems. Typical scheme is following: teacher gives classical problem. Students try to solve it. If they cannot do it, then the teacher gives little hint, for helping students. If it is not enough, then the teacher gives a second hint and wait again. He gives hints until students do not get the solution themselves. Student have to prove their solutions. Then the teacher tells a classical solution and after that compares two programs. Main parameters for comparison are time and space complexity, easy code, clear code. After discussion of solutions, we debate about about the general approach to solve such kind of problems. We believe that this discussion helps to understand their solutions and will help to solve this kind of problems in future. Sometimes the general approach to solve problems is one type of hints.

This way of giving theory allows to show the ways of problems solving. Both epy proof and finding solution themselves are helping to this goal. We believe that students cannot know all main topics of informatics and programming, but should have ability to solve new problem (it is not important is problem classical or not). Additionally a discussion about general approach is one of the most important parts of the lesson, because most of students can solve some problems but do not understand how to use this solution in the other similar problem.

Rarely we try to make our lectures as a sequence of little problems, which are solved by the way as discussed above. If we cannot do it we ask students to prepare and make a talk, teacher helps them if they need. This approach has two profit: firstly, a student who prepares a talk better understand the topic; secondly, students better understand younger student, but not old teacher.

Practical lesson is a simple online contest with problems on the topics which was learned on previous theory lesson. It gives them practice of contests and short time for solving problems.

The problems for such trainings are prepared by students of higher group (students of base group prepare problems for beginners group, students of advanced group prepare problems for base group etc.). A student who prepares problems gets skills on generating tests, stress solutions, writing statements and of course solve the problems on topics which they already know. On the one hand it allows to get the skills which helps on the contest (like tests, stress solutions and understanding statements). On the other hand it helps to remind old topics, which make their knowledge stronger.

There is no homework except up solving the problems which didn't solve on practical lesson. Also, we stimulate students to solve problems on different websites like `www.topcoder.com`, `www.codeforces.com`. This kind of "homework" is not hard work at home, but funny taking part in contests. Also, students try to up their rating on web contesters and this is additional fun. We believe that this "homework" is better, because without marks there are no motivation for students except fun and a sense of competition.

2.2. *About Groups*

Elementary group. There are only school students, who do not know programming. Here we learn only simple topics on programming language like "variables", "arrays", "cycles", "functions", but we use "olympic" problems for the lessons. University students do not follow this group, because typically they have programming lessons in their university study program.

Following groups learn algorithms, data structures and problems, which students can see in the contests. We use "spiral" strategy. It means students of the beginners group learn all main topics like algebra, text search, dynamic programming, backtracking, greedy algorithms, graph theory, geometry, data structures but simple algorithms. Students of the beginners group learn same topics and some additional, but base algorithms. Students of advanced group learn advanced algorithms of the same topics and some additional, etc.

Beginners group. In this group students have about 2–3 hour theoretical lesson and 2 hour practical lesson. Here they study simple greedy and backtracking algorithms, work with sequences, prime numbers, etcų, syntactic analysis, KMP, sorting, simple geometry problems, convex hull, BFS, DFS, Hamilton cycle, Euler cycle, simple data structures

Base group. In this group students have about 2 hours theoretical lessons and 2–3 hour practical lesson. Here they study segment trees, Binary search, LCA, phi-function, z-function, scan-line, hash, combinatorics, 3d geometry, meet-in-the-middle, Flow networks, Matching problems and others.

Advanced group. In this group students have about 2 hours theoretical lessons and 3–4 hour practical lesson. Here they learn advanced data structures and algorithms, like persistent data structures, Hungarian algorithm, integrals, probability theory problems, Numerical analysis problems, Group theory problems and others.

Professional group. In this group students have about monthly 2 hours theoretical lessons and 4–5 hour practical lesson once or twice a week. Here they solve different contests and just discuss solutions to difficult problems.

2.3. *Contests*

We organize exam contests at the end of each semester for each group. We use classical problems with little bit changes. The goal of these contests using exact algorithms, which was learned in that semester.

Additionally, we have three open online contest a year. These contests also have two or three divisions. This is not classical problems, but this is problems exactly on topics which was in the previous study period. This competition allows to train in using new knowledge in real contexts. Moreover, this contest is open and our students compete with external people.

Problems for this contest are also prepared by students from higher groups. This is an additional opportunity to remind topics from previous group.

2.4. *Training Camps*

We organize two types of training camps:

- **Training camps at the university.** Students just come to university and have a lesson. Often it is five days training. Every day they solve 5 hour contest and then they listen solution of contest's problems and some theory.
- **Training camps.** Students live in camp and have a lesson. Often it is a two week camp. Every day they solve 5 hour contest and then they listen about the solution of contest's problems and theory on next days.

Second type of camp is better, because they get more information and have less distractions. But we can organize it only once a year (often it is summer). First one less effective, but we can organize it two or three times a year.

Additionally, our students visit other training camps.

2.5. *Future Lessons*

We are planning to add new types of lessons "Hacks solutions". You can hack the solution on contesters like topcoder.com and codeforces.com. This kind of lessons allows to learn how to find mistakes in the solution and find how to fix it. It is good skills ant it is too hard to train them in regular contests.

3. Conclusion

We have big experience in teaching students to solve problems of programming contests. But in same time current situation in this area is changed very fast. On the one hand, there are new kinds of tools and new kind of opportunities. On the other hand level and knowledge of contestants become higher from day to day. In this context, we try to use new teaching techniques and sachems. We describe our current technique which we have been using for five years and we extend it year by year with new items, but at the same time it has already given good results.

Our main point is organizing of the process “students teach students”. Like in web transition from Web 1.0 to Web 2.0. It means that users make content, but not authors of web site (Codeforces, n.d.; topcoder, n.d.; KPFU, n.d.). Similar students form the content of lessons and train other students. We call this process as transitions from “lesson 1.0” to “lesson 2.0”. According to this concept teacher is converted from lecture teacher to helper or manager.

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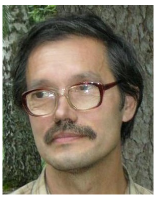

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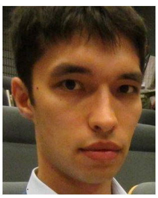

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Innopolis University and Innopolis Lyceum: Education Area of Innopolis City – the New IT Capital of Russia

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Abstract. Mission of Innopolis project is to create favourable opportunities for the economic growth of the Russian Federation through further development of Information Technology, improving the welfare of the nation and creation of a highly professional and intellectual society.

Keywords: Informatics, computer science, curriculum in IT universities.

1. Introduction

Innopolis is an IT city (Fig. 1), the first Russian university focusing on advanced Computer Science:

- Prospective population of 150 thousand people, 60 thousand of them are to be represented by highly-skilled professionals.
- Territory of more than 1,200 Ha.
- A special economic zone of technology development type and technology parks offering preferences for investors and residents.
- Comfortable and affordable housing, modern educational, medical, sports and entertainment infrastructure – implementation of the “Live, learn, work and play” concept.
- Picturesque, ecologically clean area.

The project was launched in July, 2012.

The first construction stage of Innopolis city is to be completed by August, 2015 (infrastructure for life and work of 5 thousand people).

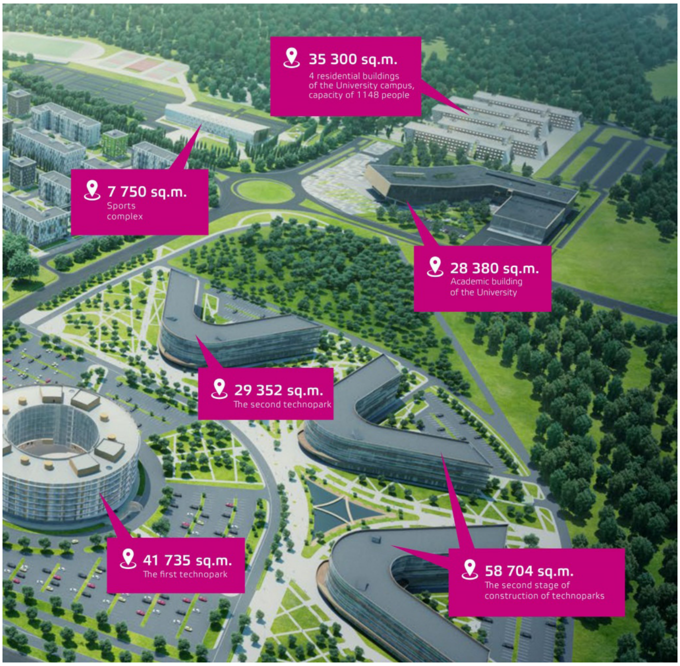

Fig. 1. Plan of Innopolis city.

2. Innopolis University: Innovative IT Education

Innopolis University (IU, 2016) is a new Russian university that focuses on research and educational activities in the field of Computer Science, is an intellectual driving force in the development of the national IT industry.

Its Bachelor, Master, and post-graduate programs are aimed at producing future specialists in cutting-edge technologies. The university also offers pre-university preparation classes and courses to enhance the competencies of experts employed in IT companies.

Functions of Innopolis University:

- Training and professional development of highly qualified IT specialists based on innovative undergraduate, graduate, and non-degree programs in accordance with international principles and requirements established in the modern IT industry.
- Conducting breakthrough fundamental and applied research in the field of Information Technology as well as development of interdisciplinary research projects.
- Creating an academic atmosphere that attracts talented engineers, entrepreneurs, investors, young specialists, students, and schoolchildren.
- Providing favourable conditions for educational, research and technology-related activities, as well as promote entrepreneurship and innovation by forming clear mechanisms of research commercialization and ensuring easy access to the appropriate infrastructure which includes premium accommodation, light, spacious

offices, modern equipment, the ecosystem for development and acceleration of start-up projects, and the attraction of venture capital investment.
- Intellectual enrichment of Innopolis city.

Study programs. Nowadays employers look for young and proactive specialists, on the one hand, and require from them broad practical experience and minimal adjustment to the internal processes in the company, on the other hand. In order to prepare students for a future job and develop their practical skills, Innopolis's study programs include more than 40% of practice in the form of team projects in every discipline. Within a final project designed for an external company, a team of students develops a programming solution from scratch through all stages: from collecting and analysing the requirements for testing a final version and submitting it to the client. This way students apply their theoretical knowledge in practice.

Bachelor's degree program. Innopolis University Bachelor's degree program, developed by the world's leading professors and IT experts, is designed to give students solid knowledge in IT. Bachelor program will provide graduates with key professional competencies required by the IT industry. The curriculum has been developed in close collaboration with top IT companies. Students will enjoy comfortable living conditions and effective educational environment in a new Russian city of Innopolis.

There are two options: 4-year program (full undergraduate program) and intensive two-year program (3rd and 4th years of studies).

Innopolis University offers the following four Master's programs – see Table 1.

Master programs. Master degrees of Innopolis University offer a high-quality IT education for young specialists and development engineers in the following programs: Software Engineering, Cyber Security, Data Sciences, and Robotics. The curriculums were designed in close collaboration with leading world partner universities. The program is available at the central location in Innopolis University, as well as in partner universities in the USA, Europe, and Asia.

Table 1

Master's programs

Program	Description	Duration
Software Engineering (MSIT-SE)	Practical learning of all stages of software development	1 year
Robotics	Industrial and scientific robotics	2 years
Secure Systems and Network Engineering	Acquiring the methods and means of keeping the data coherent, confidential and accessible in information systems. Learning the methods and instruments of preserving the data and respecting access rights to the data in computer networks.	1 years
Big Data	Definition of problems with presented data, designing appropriate models and evaluation of validity of a model. Presenting data in meaningful ways, testing for relationships within data, testing hypothesis, and carrying out modeling techniques.	2 years

3. IT Curriculum

Nowadays employers look for young and proactive specialists, on the one hand, and require from them broad practical experience and minimal adjustment to the internal processes in the company, on the other hand. In order to prepare students for a future job and develop their practical skills, Innopolis's study programs include more than 40% of practice in the form of team projects in every discipline. Within a final project designed for an external company, a team of students develops a programming solution from scratch through all stages: from collecting and analysing the requirements for testing a final version and submitting it to the client. This way students apply their theoretical knowledge in practice.

In 2015/2016 Innopolis University offers the following 4 Master programs – see Table 2.

The curriculum consists of three parts:

Core courses. The curriculum is comprised of compulsory subjects necessary for professional development of engineers (Requirements, Architecture, Management, QA, PSP, Communications):

- Introduction to Personal Software Process.
- Models of Software Systems.
- Methods: Deciding What to Design.
- Managing Software Development.
- Analysis of Software Artefacts.
- Architectures for Software Systems.
- Communication for Software Engineers.

Table 2

2015/2016 Innopolis University's Master programs

Program	Desciption	Duration	Location
Software Engineering	Practical learning of all stages of software development (applying methods of Carnegie Mellon University)	1 year	Innopolis
Software Engineering (introduction)	This course connects the curriculum of Russian technical universities and Software Engineering program	1 year	Amsterdam
Robotics	Industrial and scientific robotics	2 years	1st year – Innopolis, 2d year – partner university
Information Security	Acquiring the methods and means of keeping the data coherent, confidential and accessible in information systems	2 years	1st year – Singapore 2d year – Innopolis
Network Security	Learning the methods and instruments of preserving the data and respecting access rights to the data in computer networks.	2 years	1st year – Amsterdam 2d year – Innopolis

Elective courses. Students are given a choice of several electives, such as robotics, cloud systems, artificial intellect, and etc.

- Dynamical Software Testing.
- Introduction to Robotics.
- Advanced Topics in Software Engineering.
- Enterprise Systems.
- Affective Computations.
- Advanced Data Bases.
- Total Virtualization.
- Operating Systems.
- Basics of Information Security.
- Computer Vision.
- Cloud Systems.

Team project. Under guidance of experienced mentors, the students in teams of 3–5 will develop on their own an engineering project for an external client.

4. Pre-Master's Program

The aim of the program: To fulfil the gap in technical knowledge (OO concepts, programming in Java, algorithms, databases and English) and development experience and skills.

Intended audience: Incoming students that did not pass the admission process due to the lack of technical knowledge and/or industry experience. Length of the program: 1 year/2 semesters (Table 3).

Courses.

Practicum: 12 hours/week, 6 hours Labs with TA support.

Practicum: Students will be assigned to one of the *OpenSource* projects and contribute the code to the community. Alternatively, small industry projects might be assigned to the students.

After successful completion the students will continue their study as MSIT-SE students or select one of the academic master programs (BigData, Information security or Robotics).

Table 3

Length of the program: 1 year/2 semesters

Sem I	Object-oriented Programing	Data Structures and Algorithms	Data Modeling and Databases	Philosophy	English Language I
Sem II	Software Architecture	Operating Systems and Networks	Discrete Math/Logic	Practicum I (Java development project)	English Language II

5. Innopolis Lyceum

In January 2016, educational institution for gifted students in Mathematics and Information Technology field started functioning in Innopolis city – State General Educational Institution "Lyceum Innopolis".Lyceum's mission is creating favorable conditions for the students' full intellectual development, taking their individual characteristics and abilities into account, the formation of a future profession conscious choice and civic education. Due to the fact that all the students who have successfully passed the tests are taken to the study, whatever remote regions of the Russian Federation they live in, the boarding school is organized at Lyceum. Education, accommodation in boarding school and five meals for all students is at the public funds expense (RFG, 2014; RFP, 2010).

The Lyceum Educational program focuses on training and education of talented children who have shown outstanding ability in the field of physical and mathematical disciplines. The main objective of the program is the development of individual, creative and research abilities of students in active learning and the use of computer science and information – communication technologies. Students 7–11 grades are taught in the Lyceum in groups of 15 people It is necessary to pass the competitive tests in Mathematics and Russian language, as well as English or Tatar languages of choice for entering the Lyceum. Additionally, each applicant for studying in Lyceum provides a portfolio of individual achievements in the field of Informatics and IT, Mathematics and Physics. The peculiarity of the Lyceum is the implementation of information technology profile and convergent approach to study subjects. And this creates a maximum-variation educational environment, taking individual characteristics and needs of each student's personality into account. Residential accommodation for students allows complete immersion into studying subjects. Each of the Lyceum students has at least two additional classes after compulsory lessons per day. Mandatory courses, among them are IT sphere according to one of the directions depending on the needs and interests of students and communicative skills development (English with native speakers, as well as Chinese and German languages). For the realization of profile directions classes on the additional chapters of Mathematics and Physics are provided.

Particular attention is paid to the Olimpiads preparation, competitions and contests, research and project work. Despite the short period of functioning of the Lyceum, school Olympiads were held on all subjects to determine the abilities, skill levels and interests of each student. Over a third of Lyceum students have participated in national competitions, inter-regional competitions of the Kazan Federal University, open competitions and contests of Innopolis University. Presentation and protection of research and design works of students will be held in April, as part of the «Days of Science» in Lyceum.

The most important component and key to the success of the Lyceum is part of a highly qualified teaching staff. There are winners of the regional and the final stages of the national competition «Teacher of the year», the owners of the Ministry of Education and Science of the Republic of Tatarstan grants, the winners of the priority national "Education" project, active participants in the professional teaching community among them.

Students are engaged in sports sections (swimming, volleyball, basketball, Russian rounders, chess and others) and in the circles of artistic and aesthetic orientation (choreography, vocal, visual arts), along with intellectual pursuits. This makes it possible to strengthen their health and reduce the emotional burden.

The Lyceum's educational activities are carried out in close cooperation with the Innopolis University. The following directions are implemented in the framework of this cooperation:

- Methodological support and professional development, improving of Lyceum Innopolis teachers.
- The pupil involvement in the lyceum Olympiad movement and preparing Lyceum students for the Informatics Olympiad based in the Innopolis University.
- Development of Lyceum students' interest to the robotics design and preparing them to compete in robotics.
- Assisting in the preparation of in-depth Lyceum English language learners by engaging teachers of Innopolis University – native speakers for classes with Lyceum students.
- Organization of lectures for Lyceum students and meetings with Innopolis University teachers and representatives of leading IT companies and research centres in Russia and abroad.

Educational Lyceum programme and listed areas of cooperation with the Innopolis University certainly contributes to the empowerment of innovative technologies usage in education, the satisfaction of individual needs and students' development of intellectual abilities, formation of their conscious choice and the subsequent development of vocational training programs.

6. Pre-University Additional Studying for School Students

STEM program education in Innopolis University. To be better prepared for the workforce of the future,students need to understand and apply important concepts in Science, Technology, Engineering and Math (STEM) as well as Computer Science.

STEM programs teach students core concepts in STEM and Computer Science in programming both physical and virtual robots to creatively solve real-world problems. This learning-by-doing approach provides students with the opportunity to immediately apply the concepts they are learning through engaging projects. In effect, they are being trained as they are being taught.

Innopolis University STEM school programs employ a unique 3-tier model:

- A foundational element where core concepts in SCIENCE, TECHNOLOGY, ENGINEERING and MATH (STEM) are taught.
- A 21st Century skills element where teamwork, communications and decision-making skills are emphasized, explored and practiced.
- A project-based learning element where application of the first two tiers is conducted in real-world projects.

World Robot Olympiad in Russia. Innopolis University is a National Organizer of WRO in Russia (Fig. 2).

In 2014 the agreement was signed between Innopolis University and World Robot Olympiad Association Ltd. according to which Innopolis University is a national organizer of WRO in Russia for the future 5 years.

Institute of Robotics:

- Intelligent Robotic Systems Lab.
- Cognitive Robotic and Systems Lab.

7. Conclusions

Potential of collaboration with Innopolis University:

- Achieving the synergistic effect of coupling your experience with our expertise.
- Access to talented students and outstanding scientists.
- Involvement in the ambitious project of creation of a new growing point of innovative economy.
- Access to the state-of-the-art physical and technological infrastructure.

Innopolis University collaborates with a number of highly reputed institutions:

- Carnegie Mellon University (USA).
  `http://www.cmu.edu/`
- School of Computing, National University of Singapore (Singapore).
  `https://www.comp.nus.edu.sg/`
- Informatics Institute, University of Amsterdam (the Netherlands).
  `http://ivi.uva.nl/`
- Chair of Software Engineering, ETH Zurich (Switzerland).
  `http://se.inf.ethz.ch/`

Fig. 2. WRO (World Robot Olympiad) Russia 2014, 20–22 June, Kazan:
720 participants, 373 teams, 42 regions of Russia, 2000 guests.

- Department of Computer Science, KAIST (Republic of Korea).
  `https://cs.kaist.ac.kr/`
- Department of Computer Science and Engineering, Seoul National University (Republic of Korea).
  `http://ee.snu.ac.kr/en`
- School of Engineering, Hong Kong University of Science and Technology (Hong Kong).
  `http://www.seng.ust.hk/web/eng/`
- School of Industrial and Information Engineering, Polytechnic University of Milan (Italy).
  `http://www.polimi.it/en/programmes/schools/school-of-industrial-and-information-engineering/`
- Department of Computer, Control and Management Engineering, Sapienza University of Rome (Italy).
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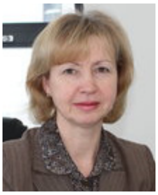

N.A. Sulimova, principal of Autonomous State General Educational Institution "Lyceum Innopolis", Honorary Worker of the general education system of Russian Federation.

M.S. Tsvetkova, professor of the Russian Academy of Natural Sciences, PhD in pedagogic science, prize-winner of competition "The Teacher of Year of Moscow" (1998), main expert of state projects of school education informatization in the Ministry of Education of the Russian Federation (2001–2005), the expert of the World bank project "Informatization of Education System". Since 2002 she is a member of the Central methodical commission of the Russian Olympiad in informatics, the pedagogic coach of the Russian team on the IOI. She is the author of many papers and books in Russia on the informatization of education and methods of development of talented students. Since 2013 she is the Russian team leader.

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Innovative Model of IT Education: The Digital Bridge "School-University"

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Abstract. There is a long standing tradition, the university graduates to get adequate training for a real-life job. Whereas only up to 10% of the graduates prefer to pursue an academic career, universities still keep teaching them to become academicians. In order to resolve this issue in 2010 Kazan Federal University and the Ministry of Telecommunication of the Republic of Tatarstan, Russia, created a new form of higher education in Information and Communication Technologies. They set up an institute within Kazan Federal University – the Higher Institute for Information Technology and Information Systems – to be a testbed for a well-known paradigm: «learning by doing» with a flavor of industrial participation in the process. In this paper we present a short overview of the model of higher education implemented in Kazan Federal University. The IT-Lyceum is a new kind of school based on a deep studying of informatics and mathematics in cooperation with university- IT education model "school-university".

Keywords: informatics, computer science, curriculum in informatics for secondary school, curriculum in computer science for university.

1. Introduction

"Kazan Federal University is one of the oldest universities in Russia, it celebrated its 210th anniversary in 2014. We celebrated this date as another token of the university's dedication to its long-standing academic mission as one of the leading educational institutions in Russia and in the world.

Kazan University has gained its international fame thanks to its distinguished scholars and graduates whose achievements have had a beneficial effect on the whole of mankind. The unique culture of our University has shaped the development of Kazan and the Volga region. The University's new federal status, obtained in 2010, poses new interesting challenges and calls for new approaches in the rapidly changing world.

Today Kazan Federal University is a dynamic modern University actively participating in local and international cooperation, networking with academia and industry, boosting the region's human resources development as well as top-level research and innovation in different areas. 17 Centers of excellence and 80 world-class research and teaching laboratories have been established in recent years. Our participation in the "5-100" competitive growth program designates our determination to reach the highest levels of world educational rankings. What we have achieved up to now is an evidence of the right choice of strategy – from a classical to a research university where entrepreneurial and innovative activities are represented prominently." (*Ilshat Gafurov*, Rector of Kazan Federal University) (KFU, 2016a).

2. KFU: Strategy '5 TOP 100'

Today Kazan Federal University (KFU) is an acknowledged center of academic excellence actively participating in international cooperation as follow:

- 190 cooperation agreements with partners from 53 countries.
- Member of 7 International Academic Associations.

The main parameters of KFU's Academic Profile are:

- 46 500 students.
- 3216 international students from 90 countries.
- 3,000 faculty members.
- 121 invited professors from world-renowned universities and research centers.
- 479 degree programs, including 85 doctoral and 8 double-degree programs with partner universities.
- 17 institutes, 3 higher schools, 1 faculty, 2 regional branches.

In 2013 Kazan Federal University became one of 15 winners of the Russian Federal Government support for leading universities open contest – "5 TOP 100". As a part of this project, KFU's mission is to ameliorate as much as possible its competitive position in the global high education and scientific research market.

KFU's Research and Academic Infrastructure contains:

- The Scientific Library "Nikolay Lobachevsky".
- 100 laboratories with up-to-date equipment and facilities with a total investment of more than 25 million euros.
- 8 museums.
- Student campus (Universiade Village) for 13,000 people.
- 11 sports and cultural facilities.
- 29 international academic and research centers.

Kazan Federal University has a wide computer network with access to Internet. All Faculties of the University have their own local networks. Every student may receive his own electronic and network addresses.

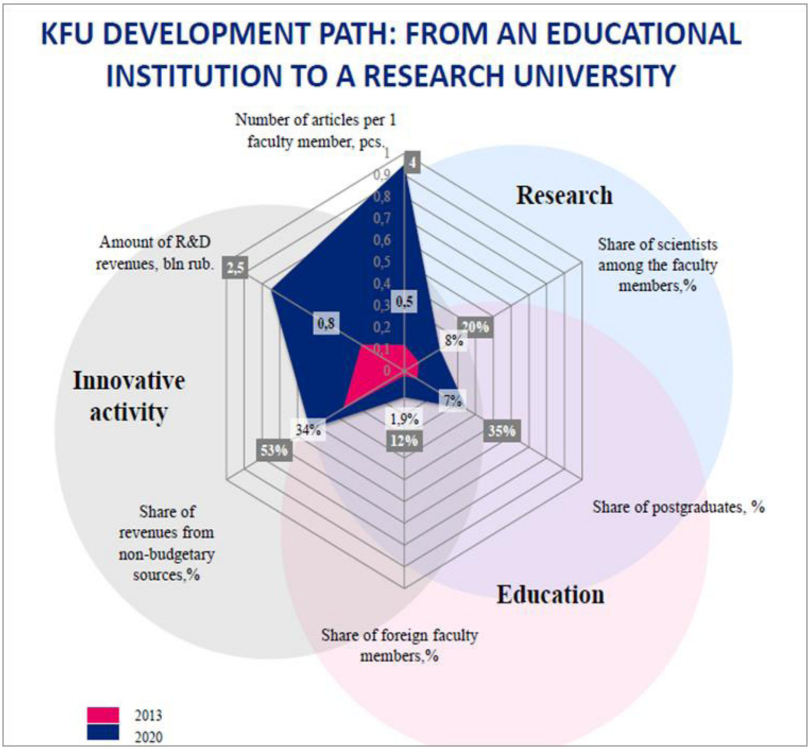

Fig. 1. KFU development path.

3. KFU: IT Degree Programmes

Bachelor Degree Programs requires at least four years of full-time university-level study. The scope of these programs is 240 credits. The programs follow a specific curriculum with an academic load of about 26-30 hours per week. The course content is fixed in accordance with the State Educational Standard. The programs consist of: 1) professional and specialized courses in sciences, humanities or socioeconomics; 2) professional training; 3) defending of a final research paper or project; 4) passing the State final exams.

Master Degree Programs require at least two years of full-time university-level study after the successful completion of a bachelor's degree. Bachelor and Master programs are summarized in Table 1.

First **Doctoral Degree programs** in IT specialization is "Computer and information sciences" (Calculus Mathematics and Discrete Mathematics and Mathematical Cybernetics) (KFU. 2016a).

Table 1

Bachelor and Master Degree Programmes

ACADEMIC FIELDS AND SPECIALIZATIONS	**Bachelor Degree Programmes**	**Master Degree Programmes**
MATHEMATICS AND MECHANICS	Applied Mathematics and Informatics Mechanics and Mathematical Modelling Applied Mathematics	Applied Mathematics and Informatics Mechanics and Mathematical Modelling Applied Mathematics
COMPUTER AND INFORMATION SCIENCES	Fundamental Computer Sciences and Information Technologies	Mathematics and Computer Sciences Fundamental Computer Sciences and Information Technologies
INFORMATICS AND COMPUTER ENGINEERING	Information Systems and Technologies Applied Computer Sciences Software Engineering	Software Engineering

4. KFU: Innovation IT Centers

Kazan Federal University pays special attention to the research in Information and Communication Technologies and Space Research.

KFU is involved in a whole range of projects with the Ministry of Telecom and Mass Communications, as well as with companies in the sphere of Info communications and Space technology. Our education and research are aimed at solving problems encountered by businesses in this area. Fundamental research is based on that conducted by the world's leading scientists.

Space research is conducted along two pathways:

- Space Technology.
- Cosmology.

Classes are conducted by professors and scientists of Kazan Federal University, and special courses are delivered by developers and engineers from major IT companies. A range of courses is taught by professors invited from universities abroad. In addition to the theory and fundamental disciplines, we pay special attention to the applied disciplines. We have more than 20 research IT labs (Microsoft lab, Samsung Android lab, IOS lab, Cisco Innovation Center, Fujitsu Lab, Robotics Lab, Intelligence Search Systems lab etc.), where students work on R&D projects.

Microsoft Innovation Centers

Microsoft Innovation Centers operate in 60 countries around the world. Several such centers have opened in Russia at the largest universities in Moscow, Yekaterinburg, Nizhny Novgorod, Tomsk, Kazan and Kaliningrad. Opening of Innovation Centers is designed as part of the Microsoft Initiative to accelerate development of the Russian software industry. Micro¬soft Innovation Center of Kazan University is an open door, "entry point" for interaction between companies with strong IT-infrastructure, small and medium sized companies, the IT-industry, universities and other research and educational organizations, government and civil society organizations in areas of research, development, deployment and commercialization of a wide range of joint projects with Microsoft. Especially - innovative, knowledge-based and interdisciplinary projects.

HP Center

HP Technology Center at Kazan University was established in accordance with the Protocol of Intent signed between Hewlett-Packard (HP) and Kazan University in March 2009. Such centers are based at the leading universities of the country within the framework of the International "Institute of HP Technology." This program was launched on January 25, 2008 and is unique for HP; it was designed and conducted by the Office of Open Innovation HP Labs. There are 20 universities in the program now including Russia, Central and Eastern Europe.

Cisco Academic Center

CISCO SYSTEMS is a world leader in networking technologies and has been the largest manufacturer of professional networking equipment for years. CISCO delivers more than 80% of the routers that make up the basis of the Internet. Modern solutions of the company, renowned for its reliability, functionality and performance, support the work of thousands of organizations, government agencies and services worldwide. The range of devices and CISCO software tools covers all applications from small private networks and small businesses to multinational companies. The actively developing project of CISCO Networking Academies serves as the training for successful professionals in the telecommunications industry worldwide. Fundamental and practical knowledge gained by students of the Academy through professionally prepared training materials and work with real equipment, offers them a wide range of positions in the IT sector in various companies and organizations. A Certified CISCO specialist is an internationally recognized standard of professional networking. CISCO Networking Academy offers their students a wide range of courses on various areas of telecommunications. The very first and most fundamental step in their training program is CCNA.

The Center for Computer Science and Computing

The Center focuses on the development of methods of mathematical modeling of physical processes, chemical reactions and methods of oil extraction; computational metabolomics; data analysis and machine learning. We plan to be among the world's leading centers of research in this area by 2020.

We are building a specialized model to develop IT systems based on combining UML diagram definitions with the apparatus of CSP-OZ theory. This combination provides on the one hand an intuitive and visual representation of graphic symbols, and on the other hand ensures accuracy and the possibility of analyzing and proving the properties of specifications received courtesy of formal methods.

The Center for Applied Algebra and Computability's research

The Center for Applied Algebra and Computability's research has focused primarily on analysis of computational complexity and quantum computation. Degrees of complexity determined by restricted resources are also investigated.

A further line we are pursuing is an investigation of how conceptions of the complexity of a computation are connected to those centered around the definition of algorithms.

Techniques developed over the course of this research will also enable the determination of the effective potential of standard mathematical theorems and the degree of difficulty present in combinatorial proof theorems.

Visualization, Innovative Interfaces, Digital Media and Computer Game Development

Digital Media Lab is a unique digital-center open at the Higher Institute for ITIS. The laboratory works with giants of digital business such as Unity Technology, DigiPen and Mail.Ru Group.

Digital Media lab developers work on projects for the development of computer games on the platforms Unity and Unreal Engine, as well as the writing of narrative and game design.

Also we work on Augmented reality (AR) projects (AR is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data).

At the laboratory we teach the theory of sound and its treatment, the creation of graphic arts as classical methods and using digital technology. Students here also learn the basics of 3D-animation, modeling, rendering and effects on Maya Autodesk and Blender platforms, as well as work with Nuke technology.

Key projects:

- 3D reconstruction of the Great Bulgaria of the XIV century and Sviyazhsk Island.
- 3D reconstruction of the Interactive Museum of Kazan.
- Talking Head (joint project with Machine Cognition lab).

Autonomous Robotics Systems

Robotics is one of the most promising branches of technology today. The Higher Institute of Information Technologies and Information Systems, Polytechnic Institute, Mathematics and Mechanics Institute, and Engineering Institute of Kazan Federal University all conduct work on robotics projects in the laboratory. R&D in the ARS Laboratory aims to find solutions to the biggest challenges facing the world today through the power of innovation. We are also involved in the creation of specialized object-oriented models and an integrated software environment based on development frame apparatus for intelligent systems design.

The Applied Big Data Analysis

KFU has been involved in the field of text development for over 20 years, and successfully collaborated in with corporations such as Microsoft and ABBYY. An analysis of global publication activity shows us that over the last 10 years, the number of publications in this area has risen from 2000 a year to 16,000. Our key partners abroad include the Max Planck Center in Leipzig and the Czech Technical University in Prague. Google is planning to use the results of the research.

Intelligent Search Systems and Semantic Technologies Laboratory
The "Intelligent Search Systems and Semantic Technologies" laboratory at KFU has substantial experience in the following research fields:

- Natural language processing (with focus on Russian).
- Scalable solutions for big data text analytics.
- Semantic web and Linked Data.
- Information retrieval.

The Laboratory of Machine Cognition
The Laboratory of Machine Cognition was opened at the Higher Institute for ITIS in 2014. Scientists at the laboratory work on the creation of Machine Consciousness.

The laboratory of Intelligent Transport Systems
The laboratory of Intelligent Transport Systems was opened at KFU in September 2014 with support from the Main Directorate for Road Traffic Safety of the Ministry of Internal Affairs of the Republic of Tatarstan. Today the organization both supervises and advises laboratory activities.

The laboratory's main aim is to increase the mobility and safety of people, as well as keep them better informed while on the road. All of our projects are already under development and devoted solely to this end.

The Center for Space Research and Technology
The Center contains the following subdivisions, which are incorporated into the Institute of Physics at KFU:

- The V.P. Engelgardt Astronomical Observatory.
- The Department of Astronomy and Cosmic Geodesy.
- The Department of Radioastronomy.
- The Planetarium.
- The Laboratory of "Wide-angle Monitoring of Fast-moving Processes in the Celestial Sphere".
- The "Sun-Earth Connection" Laboratory.
- The Metrological Area.

5. KFU IT-Lyceum: An Innovative Model of the Secondary School

The KFU IT-Lyceum is funded by the university.

Traditional model of school in Russia are the state budgetary school organizations which founders is the Ministry of Education of the region.

In recent years the separate division – lyceums with accommodation of children from 13 years (the 7th grade) are created at the majority of big universities in Russia. Earlier in Russia only four such specialized lyceums worked at St. Petersburg, Novosibirsk, Moscow and Ural (Yekaterinburg) universities. But these lyceums generally had physical and mathematical specialization and accepted gifted students only from 15 years (the 9th class). Professors of university work with such students and in these lyceum.

Expansion of a network of such boarding school-lyceums allows to capture much more gifted children and to maintain early endowments and to motivate children to scientific creativity already in the 7th grade with forces professional teachers and scientists of big university and business community of the region. It forms the educational lift "school – university – career" for gifted children.

The lyceum was opened in 2012 on the Universiade Village campus in Kazan by decree of the President of Tatarstan Rustam Minnikhanov. As a structural subsidiary of Kazan (Volga Region) Federal University, it possesses all necessary resources for all-round education of gifted children, including staff, technical equipment and IT facilities.

The IT-Lyceum boasts some innovative technical facilities. Each of the 48 classrooms is equipped with modern interactive computer equipment and comfortable furniture, and in addition the base has its own library and media hall, lecture theatre, modern computer rooms, sports facilities including a gym, and arts workshop. During the academic year, students at the lyceum live in a boarding house on-site at the school. The first half of the day is taken up by lessons, and the second by all manner of optional courses, sports, work on scientific projects, games, rest or homework assignments. Tuition is free and includes food and boarding.

In 2013, Samsung opened an interactive classroom at the Lyceum. Also on-site is a room for work with Apple products, 3D studio, print shop, language lab, and nanoeducator (an atomic-force microscope for practical assignments involving nanotechnology). Lyceum students are afforded round-the-clock care by committed teachers and tutors who devote every minute of their working day to the children. Non-academic activities – visits to the cinema, theatre, museums, and other trips – help students development and growing into well-rounded individuals.

The school caters for students from the 7th–11th Grades, and offers the chance to attend on the basis of a competition in the 7th Grade. The IT-Lyceum offers a curriculum of in-depth study of informatics, mathematics, physics, chemistry and biology. To ensure that the material is taught as effectively as possible, class sizes do not exceed 12 students. It is a boarding school and students work a full day. 300 students study and live there.

Additional, optional educational activities are laid out for students after lessons, including:

- Olympiads in informatics and programming.
- Artificial intelligence.
- Robotized systems.
- Applied mathematics.
- Olympiad in mathematics.
- A further course in Olympiads in physics/chemistry/biology.

All students achieve high scores in Olympiads and other intellectual competitions. Additional special courses are taught by professors from Kazan Federal University.

Having a lyceum within a university helps for better integration of school and higher education, allowing to discover talented students and to select gifted students to be trained for a career in the IT industry or applied ICT sciences from a young age. Supporting documents and education programs can be found on the Lyceum's website (KFU, 2016b).

IT-Lyceum mission

Society is moving towards a new level of development in the IT industry, driven mostly by high-performing IT professionals; people who while still at school demonstrate an affinity towards informatics and IT on a professional level.

Nowadays, in order to train motivated, creative specialists, prepared to combine informatics with new scientific concepts in hi-tech automated manufacturing, computer-aided medicine and other fields, one has to start early. To train top-drawer specialists it is really necessary to begin the work with talented students at school from 5th–7th grades.

The abovementioned mission enables the creation, testing and implementation of a practically-orientated model of "Career Planning", one which integrates basic and supplementary education of students at the Lyceum by means of the innovative "school – university" educational model, and which is now becoming a reality.

Informatics and mathematics programs, IT courses

In the 7th and 8th grades, students have no less than 6 hours of Informatics and 8 hours of Mathematics a week, as well as at least 4 hours of additional classes. From the 9th – 11th grades, students study informatics in more details for at least 6 hours a week, with another 6 hours of additional classes. The in-depth study of mathematics includes at least 8 hours of lessons with a further 4 hours of additional classes every week.

Optional projects chosen by the students take up to 8 additional hours every week and are tutored by scientists from KFU. Part of the lessons take place in the university laboratories alongside KFU students and scientific staff.

One of the main distinguishing features of education at the Lyceum is its heavy focus on additional tuition in IT. Acquiring such special skills is essential for students to stand out when they come to select a future profession. The lyceum offers several pathways of supplementary education centered on the theme of IT.

Robotics

Recently a significant rise of the interest in robotics education is observed. It is a multidisciplinary subject incorporating elements of science, technology, engineering, mathematics and programming. This helps the students to develop their communicative skills, teamwork and decision-making abilities, as well as their creative potential. Studying simple mechanisms, students develop their design skills, as well as their imagination and understanding the mechanical base of many objects.

The course offers lessons using computers and special interface units together with the designers. It's important to note that the computer is used as a tool for model control, trough implementing control algorithms for assembled models. The particular aspects of creating control programs, automated mechanisms and modeling systems of work are shown to the students. It is worth to note also that this course has a sporting element in it, in the form of the annual All-Russia and International Robot Olympiads.

Computer graphics, web design, 3D modelling and visualisation
The aim of this course is students to master the necessary theoretical and practical skills in the field of web design and three-dimensional graphics. After finishing the course the students:

- Possess complex theoretical and practical abilities which enable them to solve applied tasks in three-dimensional graphics.
- Could use basic concepts and classes of objects of three-dimensional graphics.
- Could differentiate between image formats and colour-representation systems in computer graphics.
- Could build hierarchically-linked systems of three-dimensional objects.
- Could model low and high polygonal models of technical materials and real-world objects.
- Could edit raster images in Adobe Photoshop.
- Could process vector graphics in CorelDraw.
- Could create 3-D images and animations.
- Could make web pages using HTML and CSS.
- Know the basics of engineering graphics.
- Could develop design projects.

System administration
This course is dedicated to the hardware and basic software of computers. Upon completion of the course students are able to describe computer's internal components, assemble a computer system and install an operating system, as well as discover and fix problems using service and diagnostic programs. Students are also able to connect to Internet and share access resources in network environments. The main aim of the course is to prepare students for entry-level positions in different areas of IT.

The Samsung IT School
This is an additional programme focusing on the basics of IT and programming, and comprises six modules:

- Basics of programming (in Java, C).
- Object-oriented programming (in Java on Android).
- Algorithms and data structures (in Java on Android).
- Basics of information security.
- Introduction to DBMS (for example SQLite).
- Introduction to the World Wide Web.

Classes are taught in a specially-equipped classroom. The goal of the course is to develop a student's complex knowledge in the field of IT and teach them to:

- Develop simple mobile apps.
- Work with Eclipse and Android SDK Tools.
- Use basic programming-language constructions.
- Learn and apply object-oriented programming when solving problems.
- Work as part of a team.
- Solve various programming problems.

- Have a good command of basic concepts of web technology.

Students develop a mobile applications as a graduation project and receive a certificate upon successful completion of the course.

Radio electronics

This area of science and technology continues to peak the students' interest. Applying theoretical knowledge of physics and mathematics and working with professional instruments and measuring equipment, students create their own electronic devices.

All of these academic pathways are studied in depth in KFU subsidiaries – the Institute of Physics, the Higher Institute for Information Technologies and Information Systems, the Institute of Engineering and the Institute of Computer Mathematics and Information Technologies.

6. Students and teachers at the KFU IT-Lyceum

The Lyceum offers tuition to boys and girls between the ages of 12 and 18 who are interested in science of informatics and have a passion for creative technologies.

Many students at the Lyceum distinguish themselves by their achievements in creative technologies. Projects implemented by Lyceum students win prizes at all manner

Fig. 2. In the IT Lab.

of competitions. One such project, implemented by Omar Zeinalov, was listed among the 50 best innovative ideas in Republic of Tatarstan. The project is titled “Smart Street” and is devoted to saving energy by means of automating street lighting. Its creator was awarded the President of Republic of Tatarstan’s prize dedicated to support young talents. Another project, implemented by Daniyar Sadykov, was evaluated as important and significant for personal data protection by cyber-defence specialists Kaspersky and network equipment corporation CISCO. The idea of the project was to create technology for ultra-safe data transfer.

The KFU IT-Lyceum has a teaching staff with an average age of 36, many of them have won professional competitions or have authored scientific articles for highly-rated academic journals.

The Lyceum’s teachers help students to gain an in-depth knowledge of their subject, as well as instilling a sense for the importance of professional self-determination, encouraging them to search, select and independently solve problems, and fostering a proactive mind set in the students when it comes to learning the modern workplace.

Students work in close partnership with scientists at KFU, whose activities further raise the level of teaching. By incorporating recent scientific achievements into the educational process, it is possible to decrease the gap between the school curriculum and the scientific research activities. Further in-depth instruction is planned for older students on an individual basis in their chosen area of fundamental sciences.

One of the main tasks of KFU is to develop the creative abilities of its students. This is achieved mainly by means of a structure of special courses, seminars and classes for solving typical problems.

After their classes, students at the Lyceum meet with their tutors. Tutors are intelligent, approachable professionals who teach the students and are always ready to come to their aid and offer them support when they are far from home. The opinions of some students and parents follow:

> *I really like studying at the KFU IT-Lyceum. Our teachers give us a lot of attention and our tutors are kind. We often go on class trips and visit museums and exhibitions. The last and most interesting one was when we went to the laboratories at Kazan Federal University.*
>
> (Nail Karimov, 7th Grade)

> *In the world of Information Technologies, it’s important to have a good education. For me the Lyceum has been like a springboard to scientific discoveries. It gives us the knowledge base we need to become great and educated people.*
>
> (Iskander Tukhfatullin, 7th Grade)

> *As someone in their 4th year at the KFU IT-Lyceum, I can say that every year the living conditions get more and more comfortable and the study plans wider and more useful for the future. The lyceum has helped me clearly define my life goals and start making them a reality.*
>
> (Ruslan Khairutdinov, 11th Grade)

There are many advantages in my son's education at the IT-Lyceum: on the one hand it has provided him with a stronger grounding in the core subjects (the textbooks they use are of high degree of complexity), and on the other hand it has afforded him the opportunity to express himself creatively through project works. The lyceum offers many optional courses and other organised activities of interests – my son really enjoys the optional course in robotics. The students day is structured in such a way that all time is accounted for, and my son is always under the watchful eyes of his teachers, form teacher and tutor. It's also very convenient how the school and boarding house are located in the same building in the Universiade Village campus, which is guarded 24/7.

(Lyudmila Danilova, mother of Kirill Danilova, 8th Grade)

7. Conclusion

KFU's mission in IT is to bridge the gap between academia and the requirements of industry, and to allow researches from different disciplines to link together. Our goal is to create specialists who not only match current development in technologies but regularly outperform them, bringing to industry the innovations created at the University. Our research is either theoretical in nature or geared towards solving real problems facing real industry.

The best KFU researchers and developers from the Higher Institute for Information Technology and Information Systems, Institute of Mathematics and Mechanics "Nicolay Lobachevsky", Institute of Computer Mathematics and Information Technologies all work together on autonomous robotics systems, software engineering, computer science, artificial intelligence, and digital media R&D projects.

The lyceum has only been in operation since 2012, but has already had some significant successes:

- First-prize winners at the final stages of All-Russia Olympiads in Informatics, Physics, Astronomy, Chemistry and Biology.
- More than 100 champions and other prize winners in All-Russia and international IT competitions, conferences and competitions in robotics and team-programming.

Student achievements can be viewed on the IT-Lyceum's website (KFU, 2016b).

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Contest "Bebras" on Informatics in Russia and Belarus

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Abstract. The paper presents an experience of work with gifted schoolchildren in the field of informatics within the International Contest "Bebras". The idea of tasks that develops algorithmic or computational thinking is presented. The on-line Russian site of the contest and its coverage of schoolchildren of Russia and Belarus is demonstrated.

Keywords: Informatics, algorithmic and computational thinking, electronic educational resources.

1. Introduction

International educational collaboration in the form of intellectual contests of schoolchildren from different countries is developed within global communications. An example of such a collaboration is an intellectual contest on Informatics "Bebras" (2016), that was joined by the Russian Federation in 2012, and by Belarus in 2015.

One of the organizers of the contest Bebras is Valentina Dagienė (Lithuania, Vilnius University), a specialist of International Olympiad in Informatics. She founded Bebras contest in 2004 and now more than 40 countries all over the world participate in it.

2. Russian History of the Bebras Contest

In 2004, the contest «Construct, Test, Explore» (CTE) was founded by the Center of Information Technologies in Education "CTE", Russia (2016). Its main feature was support of a long experimental-research activity with a model of some idea of the field of informatics or discrete mathematics, that still did not have a full theoretical solution, or its solution was hard (Ivanov *et. al.*, 2004). In this contest participants got three virtual laboratories on one week, during which they could hold experiments in an interactive mode. The software tested a participant solution to comply with the statement and also assessed how close it was to the optimal according to criteria formulated in the statement.

In 2012, the team of CTE contest developers and organizers joined the organization of the BEBRAS contest, that had already been held in 19 countries. Previously, at the seminar at Gargano, Italy on 9–11 Oct, 2011 a declaration to use the format of this contest to unity mass contests in informatics for all countries had been adopted.

The Center for informatization of education "CTE" had already developed a system to hold various competitions, and used it to hold the Bebras contest in Russia.

3. Tasks of the BEBRAS Contest

In the Bebras contest, the work on tasks is the main tool, uniting its organizers in different countries, thanks to an annual seminar, that gathers representatives of more than 40 countries. During 4–5 days they discuss and correct tasks, presented by participating countries and participation candidate countries.

Different countries according to their traditions of informatics formation pay attention to different aspects of computational (or algorithmic) thinking, that results in the versatile set of tasks that demonstrates new aspects of informatics.

Tasks usually have a textual form analogous to a Kangaroo (Kangaroo in Russia, Institute of Productive Learning, RAE) (2016) competition in mathematics that appeared before. The difference is that there are less problems and a wrong answer (choice of a wrong answer from four presented) subtracts one third of the task's scores. The time to solve problems is about one hour. One may find detailed competition rules at `http://bebras.org` and `http://bebras.ru`.

Tasks cover rounds for 1–2, 3–4, 5–6, 7–8, 9–11 grades. Everybody including teachers and schoolchildren have free access to collections of tasks of previous years.

Fig. 1 presents an example of a task, where participants get acquainted with an idea of pattern recognition based on a neural network. A statement presents a network that recognizes "chairs", "armchairs", "stools" with different weights for different features such as a presence of a "back", "arms", etc. The question is to find a furniture on the presented set, that will not be classified by the network.

It is important for participants to know whether their answer is correct, and to read the solution. Fig 2. demonstrates the view of the solution.

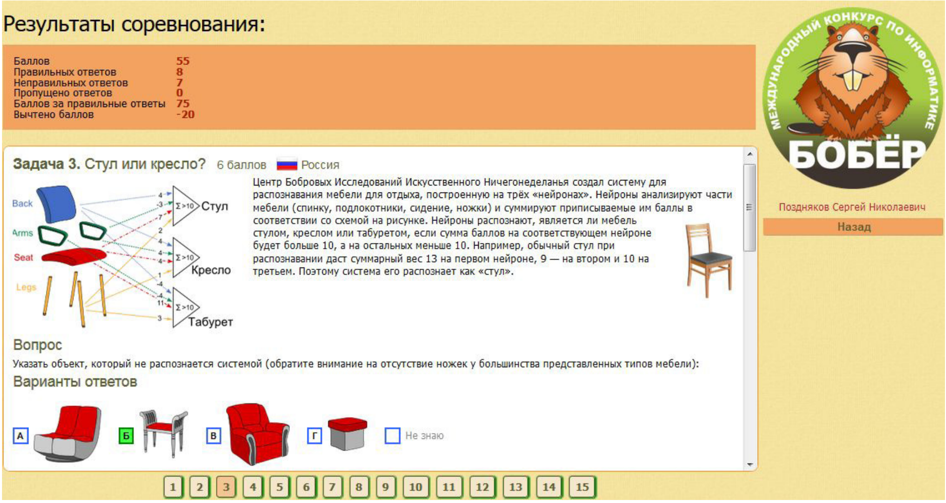


Fig. 1. An interface of a problem when a participant overviews results.

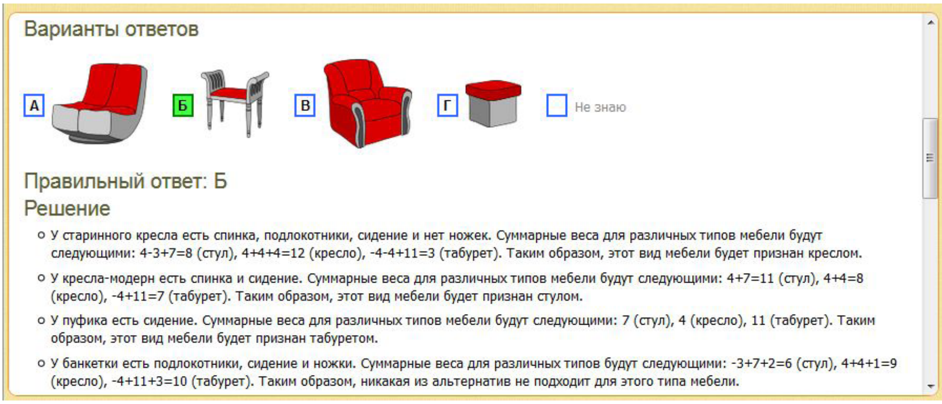


Fig. 2. Explanation of the task about pattern recognition.

Here is an excerpt from the explanation of the task "Chair or an armchair?", how is it connected to informatics:

The system presented in the task is designed to classify any object in one of the four categories: chairs, armchairs, stools, or others. Neurons are simple components, that compute a sum and are "activated" if the result is greater than the threshold, corresponding to the neuron. This simple model is surprisingly close to what biologists know about real brain neurons. The numbers they sum are sometimes called input weights, because they correspond to the significance of each feature in the classification problem. For example, the presence of a sitting is a very important feature of a chair, while the presence of legs is almost irrelevant for armchairs.

Generally, a neuron is a compact way to express an otherwise complex rule. Since all the inputs are just binary (true/false) properties, you can see that by writing a table with all the possibilities. For the "Chair" neuron it is shown in Table 1.

Now we present another example of a Bebras task. It was proposed by the Russian delegation to the Bebras tasks workshop in 2015, and it can be considered a typical Bebras task, because it was selected among the best tasks of that workshop (Dagienė and Futschek, 2008). It is a task about representation of information with graphs. We retain the original split of the task into sections, used in the workshop:

Title: Beaver the alchemist.
Body: Beaver the Alchemist can convert objects into other objects. He can convert:

1. Two clovers into a coin.
2. A coin and two clovers into a ruby.
3. A ruby and a clover into a crown.
4. A coin, a ruby, and a crown into a kitten.

After the objects have been converted to another object, they disappear. (see Fig 3)

Table 1

Table of variants for the task "A chair on an armchair?"

	Back	Arms	Seat	Legs	Sum	Classification
Weights	4	–3	7	2		
	0	0	0	0	0	Other
	0	0	0	1	2	Other
	0	0	1	0	7	Other
	0	0	1	1	9	Other
	0	1	0	0	–3	Other
	0	1	0	1	–1	Other
	0	1	1	0	4	Other
	0	1	1	1	6	Other
	1	0	0	0	4	Other
	1	0	0	1	6	Other
	1	0	1	0	11	Chair
	1	0	1	1	13	Chair
	1	1	0	0	1	Other
	1	1	0	1	3	Other
	1	1	1	0	8	Other
	1	1	1	1	10	Other

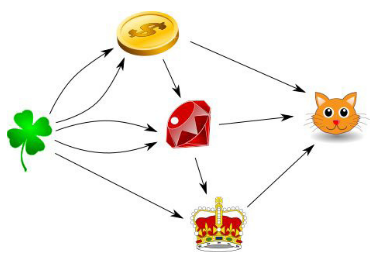


Fig. 3. Task " Beaver the alchemist".

Question: How many clovers does Beaver the Alchemist need to create one kitten?
Answer: A. 5, B. 10, C. 11, D. 12

(Actually, this set of answers was presented to participants of 5–6 grades, elder participants had to input a number into the text box)

Explanation: The answer is 11. We can see the conversion as follows:

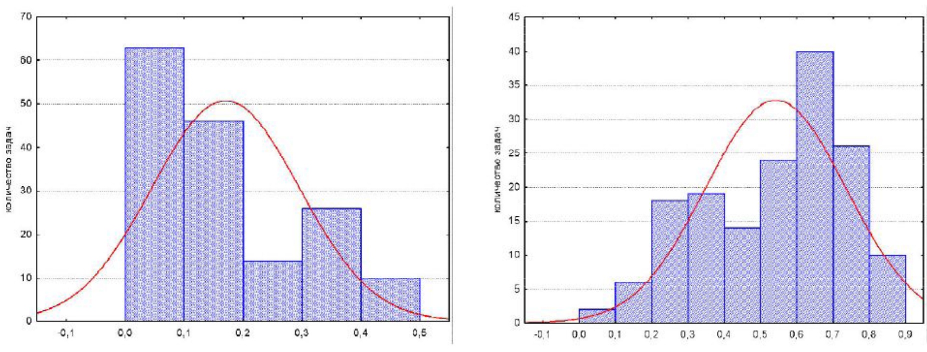
coin	=	2 clovers
ruby	=	2 clovers + 1 coin = 4 clovers
crown	=	1 ruby + 1 clover = 4 clovers + 1 clovers = 5 clovers
kitten	=	1 coin + 1 ruby + 1 crown = 2 clovers + 4 clovers + 5 clovers = 11 clovers

The answer 5 is for those who did not read the graph properly to realize that we need 2 clovers to create a coin or ruby, or for those who did not realize that you need a coin to create a ruby or a ruby to create a crown. The answer 10 is for those who think that the number of clovers is the same as the number of edges. The answer 12 is for those who miscounted.

It's informatics:

This task demonstrates how graphs can be used to represent dependencies between items. A graph is a data structure that is used a lot in informatics to demonstrate relationships. The graphs also make it easier to visualize a task compared to just reading the descriptions of the relationships in the text.

Note, that the scores system of the BEBRAS contest assumes subtracting one third of scores for a task in the case of a wrong answer. Simple evaluations demonstrate that a random choice of an answer will give at the average the same result as the refusal to give any answer (select "I don't know"), thus, the refusal to solve cannot be explained by a "strategical" considerations of a participant. The analysis (Yagunova and Ryzhova, 2013) showed, that there are two objective characteristics of a task: its hardness and its complexity. Assuming only participants who started to work with a task, the complexity is a percentage of participants who selected the answer "I don't know", and the hardness is a percentage of participants who did not give the correct answer. Fig. 4 demonstrates



a b

Fig. 4. Distribution of tasks by complexity (a) and by hardness (b).

the distribution of BEBRAS tasks by complexity and by hardness (for the 2012th, the first BEBRAS year in Russia).

The distribution differs from the normal and has an apparent left asymmetry for the first one, and a right asymmetry for the second. This means that the tasks of the contest that year seemed not complex for participants, but occurred to be harder, that they thought.

For tasks authors, such distributions say a lot: they show, that the authors managed to overcome an entry barrier, i.e. they managed to express the task's statement in the way that seemed understandable for participants and made them ready to solve a task.

4. Software Support of a Competition: Main Principles and their Implementation

The Bebras contest is supported by a specially designed competitions system called DCES (Distance contests execution/educational system, implemented in Java, Play framework and MongoDB). It is designed to support different types of competitions with different regulations. One of the other competitions held by the system is a CTE contest (Posov and Maytarattanakhon, 2014). To implement some competition, one should use corresponding types of tasks, specify the process of collecting answers for separate tasks and the process of merging them into the result of a competition, set up a timing with the set of actions available for participants during different time segments. Everything that follows assumes only the Bebras contest.

There are two types of tasks used by the Bebras contest. The first is a simple choice of an answer from four presented variants. A participant may always select the fifth special variant "I don't know", if her or she does not want to give an answer. This is important, because rules specify that the wrong answer should subtract a certain number of scores.

The second type of a task is a dynamic task. These are the tasks that have arbitrary interaction, which should be implemented in almost pure JavaScript by a task author. There are libraries that automate the implementation of tasks with drag-and-drop interaction, such tasks usually ask to drag objects to the correct place. And there is a library to implement problems with a text field for an arbitrary text answer. One can adjust the input mask and a reaction to an incorrect input.

All dynamic problems also allow a participant to say "I don't know", the interface makes it obligatory for a participant to press a button "provide an answer" after he or she makes his or her actions to a task. After this button is pressed, he or she may press the button again to remove an answer and thus say "I don't know".

All tasks used in Bebras contest are entered into the system before the competition by filling the following fields: a statement, a question, a set of answers or an interaction depending on the task type, an explanation containing the correct answer, "It's informatics" section, that explains to a participant, how the task is connected to informatics. This separation to fields corresponds to the way the task is prepared by the international workgroups.

The competition is held online, and participants read problems and enter answers with computers. This means that the system has certain requirements to storage stability of answers given by participants. All answers are sent to a competition server as soon as they are given by a participant. If a computer goes offline, answers are stored in a local storage and are sent to the server as soon as computers goes online again, even if it goes online after the competition has finished. Thus, any page reloading, computer reboot does not make answers lost. It is impossible to extend the time given to a participant (40 minutes) due to technical problems on a participant's side, the only possible thing is to reset all participation data for a participant and allow him or her to participate again.

The system supports highly configurable user roles. Roles usually include participants of a competition, school organizers that manage participants from their schools, higher level organizers, that manage school organizers, etc. The roles hierarchy differs for different competitions, and even in the Bebras contest in Russia and in Belarus, it depends on the established participant registration process.

5. An Experience of the Contest Execution in Russian Federation

In Russia, the Bebras contest is held within a program of Russian academy of education called "Productive education for everyone" and addresses the following aims:

1) To develop an interest to informatics, discrete mathematics and information culture.
2) To enable everybody who wants to participate and to achieve some success. A motivation for such communion is a game component and a week depending on achievements in school informatics, thus tasks are mainly aimed at quickness of wit and intuition.
3) To enable schoolchildren, who are considered making week progress for various reasons, to express themselves. That is why contest tasks differ from tasks suggested to them in informatics lessons, and are not connected to any specific curriculum in informatics or textbooks.
4) To help teachers to improve their qualifications.

The organization of the Bebras contest is held by the center of informatisation of education "CTE", operating on the basis of Saint Petersburg Electrotechnical University (ETU). To work with teachers and participants, the site with automated registration, contest execution and results processing (`http://bebras.ru`).

The faculty of computer science and technology works quite long on establishing a sequence of gradually complicating activities that lead a schoolchildren from a mass competition to an olympiad.

Currently, there are three stages, with the Bebras contest being the first:

1. Bebras: the mass contest on informatics.
2. "Construct, Test, Explore" (held about 15 years) (`http://kio.spb.ru`). The contest, presenting each year three nontrivial virtual laboratories, supporting re-

search activity of schoolchildren. After the contest, these laboratories are used on teacher training courses and to support school sections on informatics.

3. The Olympiad in discrete mathematics and computer science for 9–11 grades (2016). The olympiad combines an idea of constructive work with computer models and tools with tasks, based on theoretical analysis of experiment results. The olympiad is held in December (the qualifying round) and March (the final round). In 2015–2016, 18 leading Russian universities participated as co-organizers.

All participants of the Bebras contest get a certificate with participation results. For those who are near to the top of the competition rating, their exact position in the rating is indicated, for others, their certificate does not contain this information. Fig 5. shows the poster with the information about the competition in 2015.

Fig. 5. Poster with an information about the Bebras contest in 2015.

6. An Experience of the Contest Execution in Belarus

Understanding the importance of the development of schoolchildren interest in informatics and latest in programming, Belarusian State University of Informatics and Radioelectronics became a Belarus coordinator of the Bebras competition. Information support to the contest was provided by the Ministry of Education of Belarus.

The participation of Belarus schoolchildren in this important and significant event became possible thanks to the great help of colleagues, specialists from Russia, who, at this stage, provided technical and methodical support of the contest in Belarus.

In October, 2015, in Belarusian State University of Informatics and Radioelectronics, a two-days seminar for responsible coordinators of the contest from all regions of the republic. The seminar was held by a national Russian coordinator Sergei Pozdniakov.

About 60 thousand schoolchildren of 1–11 grades took part in the contest. The most active were participants from the Grodno region (14248 part.), the Brest region (9066 part.), and the Vitebsk region (8840 part.).

The organization and coordination of the Bebras contest in regions were conducted both by regional representatives, and also directly through the communication of school organizers with the Organizing Committee.

Belarus schoolchildren showed great interest in solving competition problems and demonstrated good results. Diplomas of the I, II, III grades were given to 2155 participants (2016), including 67 participants, who got the maximal scores, 81% of whom are from 3–4 grades. About 30% winners of the contest got the diploma of the I grade. Significant are the results of participants from the 1–2 grades, 27% of their winners got a diploma of the I grade, and also the results of participants of 7–8 grades, 32% of their winners got a diploma of the I grade.

7. Conclusion

A participation in such intellectual contests allows to encourage and improve motivation of schoolchildren in the usage of modern information-communication technologies, allows to improve the level of computer literacy of pupils, their algorithmic and computational thinking, and also to activate creative activity of teachers. This will then allow schoolchildren and their teachers to master new methods and algorithms for solving problems.

Important are the cognitive, social, cultural and intercultural aspects of the international contest.

The main feature of the contest is its coverage of younger schoolchildren, that is, it allows children motivated in informatics to make a start.

In the opinion of the expert in informatics olympiad in Russia, prof. M. S. Tsvektova, "informatics in the 21st century experiences a transformation in contents, because a school becomes filled with the new generation of children: the generation Z. For these young schoolchildren informatics is an integral part of the digital world, surrounding them. That is why it is extremely important to give children an ability to find themselves in informatics by means of different intellectual competitions. The mathematical contest "Kangaroo" in 1–4 grades is very popular in Russian schools. But children are interested in doing something with computers. Thus, informatics in primary school has been already taught already since 1990. Informatics is included in the state educational standard of primary education (1–4 grades), there exists a handy curriculum for schools, various textbooks are developed. And, of caurse, there exist talented kids. That is why the development of contests for young schoolchildren is urgent. Russia has such an experience, these are contests "KIT", "Infoznayka", "Trizformashka", "Informashka", the contest on Scratch (2016). Because of these contests, children may become familiar with olympiads, and to show very strong results already in the 5th grade.

Concerning olympiad movement in informatics for schoolchildren of 5–11 grades, it involves schoolchildren of our country within the all-Russian school olympiad that is held in the country on 24 school subjects. Among them, the all-Russian informatics olympiad has been held for 28 years. However, children of the 1–4 grades are not included in this movement.

It is very important to support children of primary school keen on informatics with various creative competition, but it is very hard without a partnership with teachers. It is important, that the Bebras contest the registration of a child-participant is done by his teacher or an instructor. We hope, that the Beaver competition will find its interested audience not only among children, but also among teacher of the primary school both in Russia and in commonwealth countries".

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Concept of Algorithmic Problems for Younger Students Olympiads in Informatics

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Abstract. The concept of algorithmic tasks for younger students olympiads in informatics is presented in this paper. This concept is based on development of various types of algorithms with help of interactive environment of computer decision modeling based on control commands of executor. This environment creates a range of visual forms of information objects – command executors and immerses the child in the problem situation defined by executor behaviour.

Keywords. Informatics, computer science, younger students olympiads in informatics, preparation for olympiads in informatics, methods of work with talented children, developmental teaching.

1. Introduction

The concept of algorithmic problems for 5–9 year old children is based on development of various types of algorithms with help of interactive environment of computer decision modeling based on control commands of executor. The environment creates a visual imagery of vivid images of information objects – executors of commands – and immerses the child into a problematic situation determined by behavior of executors. Software implementation of solutions of such problems is carried out with help of a set of control commands of executor offered to the child. Own set of control commands for each executor is built in the interactive environment. It can be called "executor command language". This language is not programming language, but allows to accomplish linear and selection algorithmic constructs, and loops for a particular computer executor of commands.

The child selects commands using the mouse cursor and sees the resultant reaction on the screen. The decision is saved in a personal file on the computer in the form of a command set. Wrong step solution appears with a message on the computer screen and allows to enter a correct step (reflection of the solution step). The control command set of each executor is embedded in the interactive environment of the laboratory. It can be referred to as the “executor command language (hereon ‘ECL’)”. This is not a programming language, but enables the realisation of algorithmic constructs: linear, conditional and cyclic for a specific computer executor command.

The “Virtual Informatics Laboratory” (Fig. 1) interactive learning environment includes six types of algorithmic problems. Each laboratory has its own executors, which are described using “living” prototypes from the surrounding world. The resource is publically available on the BINOM methodical service portal (BINOM, 2015) – official website of the publisher BINOM with a free suggested materials in the Russian: an archive file of the product, manual for working with the product and examples screen for solution steps (BINOM, 2008), video lecture for the teacher, the methodical book for teachers (Tsvetkova and Kuris, 2008). Program implementation of solutions to these tasks is carried out by the child’s choice of executor control commands on the computer screen.

Each laboratory is geared towards a particular algorithmic problem:

1. Overflows (simple run-through).
2. River crossings (conditional selection).
3. Weightings (run-through with choice).
4. Black Boxes (determination of an algorithm according to known input and output data).
5. Rearrangements (run-through with limitations).
6. Passings (work with stacks).

Each group of problems comes in three levels of complexity set by the input data. Methodical description of all tasks in all the laboratories is found in the book (BINOM, 2015). The “Virtual Informatics Laboratory” learning environment can be used in various plans:

- Demonstrating the solution to a few of the problems.
- Individual training work with a selection of problems in a chosen group.

Fig. 1. The “Virtual Informatics Laboratory” interactive learning environment.

- A competition to put together a packet of problems (one from each group), against time.

The learning environment informs the student of:

- A correct solution.
- An error in the solution.
- The optimal solution.

The system awards points to students for their solutions, depending on how they carry out the tasks:

- 0 points – erroneous or absent solution.
- 1 point – correct solution, but not using the optimal number of operations.
- 2 points – optimal solution.

2. Tasks Group “Overflows”

Overflow tasks help children virtually use concepts like “container capacity”, “units of measuring volume” and “part and whole”; and to model solutions using several containers. Solving problems of this type facilitates more intensive logical thinking while running through possible options.

The “overflow” group provides several types of tasks:

- **Type 1 tasks**. Open system. Unlimited supply of water. The source (S) and terminus (T) are active in this kind of task. There are 6 levels of complexity.
- **Type 2 tasks**. Locked system. Dividing a liquid into container(s) using additional containers. Source (S) and terminus (T) are not used in this task.

Typical ECL commands:

```
< fill > : [X], [n]
< transfer > : [X] , [Y] , [n]
< drain > : [X], [n]
```

Explanation:

`X`, `Y` – denote the capacity of (A, B…) specified capacity in liters

n – the number of litres Example the screen for solution steps “Overflows”

Example task “Overflows”

You have two watering cans: one empty with a capacity of 3 litres, and one full with a capacity of 5 litres. How can you obtain 7 litres of water from the tap?

The solution as an algorithm.

```
start :
1. < transfer >: [B], [A], [3]
2. < drain >: [A], [T], [3]
3. < transfer >: [B], [A], [2]
4. < fill >: [S], [B], [5]
End
```

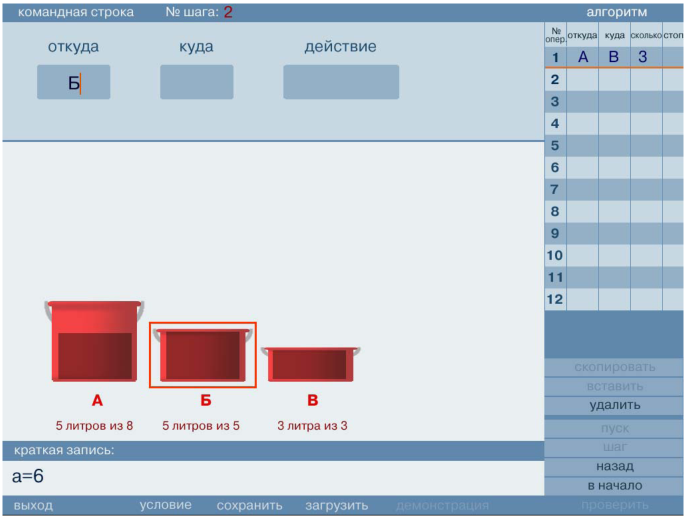

Fig. 2. Examples screen for solution steps “Overflows”.

3. Tasks Group “River crossings”

Performing river-crossing tasks enables a child, working using common sense (the relationship between various crossing participants), including spatial awareness and intuitive reasoning, to plan a sequence of actions and write an algorithm, taking into account the complexity of the task. The difficulty of river-crossing tasks lies in the load-bearing limitations of the raft, and the quantity and peculiarities of the passengers (their possible combinations).

Typical ECL commands:

```
< get on > : [X]
< get on > : [empty]
< cross > [A], [B]
< get off > : [Y, ...]
< repeat > Point1, Point2, n
```

Explanation:

`X` – the passengers for boarding
`Y` – the passengers for the landing
`A`, `B` – the pointers of the banks
`Point1`, `Point2` – the number of commands to repeat
`n` – the number of repeats

Example task “The goat and her seven kids”

A goat and her seven kids are going to grandma’s house on the other side of the river, on the right-hand bank. The goat does not want her kids to cross without her, but the raft can carry no more than 2 passengers. How can they all cross the river in the most rational manner?

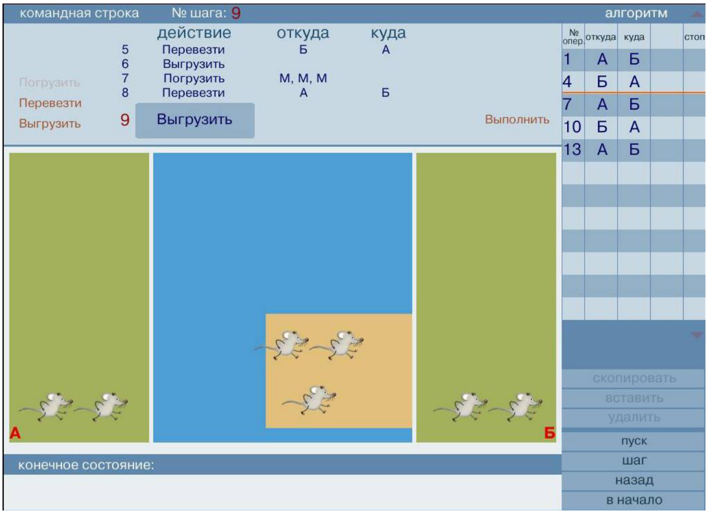

Fig. 3. Example the screen for solution steps “River crossings”.

Representation of the solution as an algorithm.

```
start:
1. < get on > : [Kid]
2. < cross > : [1] , [2]
3. < get off > : [Kid]
4. < cross > : [2] , [1]
5. < repeat > : commands 1,2,3,4 while > 1 kid remains on the left-hand
bank.
6. < get on > : [Kid]
7. < cross > : [1] , [2]
8. < get off > : [Goat].
end
```

4. Tasks Group “Weightings”

Weightings tasks teach children to select efficient sequences of actions using the relationships “lighter” and “heavier”. Comparison is a logical approach used to establish the similarities or differences between objects. The result of a comparison is described by the terms “equal”, “larger” or “smaller”, depending on the relationship of objects for comparison.

In tasks of this type, not only single objects are compared but also groups of objects. This forces the child to analyse his or her actions and “think through” all possible combinations to find a solution.

Typical ECL commands:

```
< compare >: [x], [y] ,
```

```
If [x] = [y] ,
Elseif [x] > [y] ,
Endif ,
< choose > : [X]
```

Explanation:

`X, Y` – objects for weighing

Example task “Fake coins 4”.

A merchant has 6 coins, 1 one of which is false and lighter than the others. Suggest a way of finding the fake coin with the minimum number of weighs on a set of scales. The real coins are all of equal weight.

Representation of the solution as an algorithm:

```
start:
1. <compare>: [1,2], [3,4]
2. if [1,2] = [3,4]
3. then < choose > [5,6]
4. <compare>: [5], [6]
5. if [5]>[6]
6. then < choose > [6]
7. else < choose > [5]
endif

else
2. if [1,2] > [3,4]
3. then < choose > [3], [4]
4. <compare>: [3], [4]
5. if [3]>[4]
6. then < choose > [4]
```

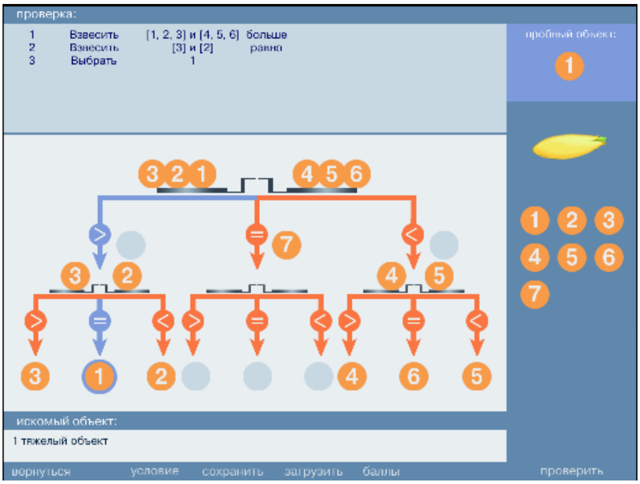

Fig. 4. Example the screen for solution steps “Weightings”.

```
7. else <choose> [3]
endif

else
2. if [1,2] < [3,4]
3. then < choose > [1], [2]
4. <compare>: [1], [2]
5. if [1] > [2]
6. then <choose> [2]
7. else <choose> [1]
endif
```

5. Tasks Group "Black Boxes" (Mathematical Operations with Numbers)

The reinforcement of mathematical principles in relation to the educational standard:

. Calculating operations
. Comparison operations
. Order of actions
. Number composition

Primary recording of arithmetical and logical expressions, order of calculations in arithmetical expressions, modelling mathematical records of number composition tasks.

ECL description.

```
take <x> - take some value of X
<operation> - perform an operation according to the formula present
Brackets: (  )
```

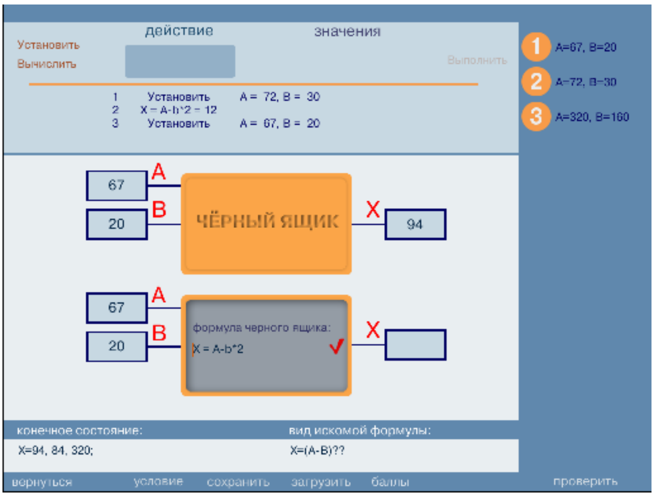

Fig.5. Example the screen for solution steps "Black Boxes".

`< Number composition >`

`A <comparison operation> B`

Only two-way comparisons are used in this group of operations, but there could be formulae on either side of the comparison.

Explanation:

`X` – expression

`A, B,..` – operands

Examples of task conditions.

<table>
<tr><td>«Scattered numbers»</td><td>At the entrance of the Black Box is the number a, comprised of 7 tens, 3 hundreds and 5 units.
Complete the formula using the information of the Black Box, the number 10 and multiplication and addition.
<table><tr><td>a</td><td>=</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>
Some cells may remain empty if they are not necessary for the result, and this will not affect the accuracy of the answer.
The Black Box will calculate the number according to the formula and say whether it is correct or not.</td></tr>
<tr><td>“Compare”</td><td>At the entrance to the Black Box there are 3 mathematical expressions.
It compares their results and completes the table using comparison operations.
Complete the table for the mathematical expressions provided by the Black Box. Put “>”, “<” (change ‘?”)
25 × 5 ? 100 – 25 ? 4 × 25
14 × 14 ? 14 + 14 ? 2 + 14
18 × 3 ? 9 × 6 ? 3 × 18
The Black Box will check it and say whether the task has been solved correctly.</td></tr>
<tr><td>“The secret of the brackets»</td><td>The magic Black Box can calculate quickly. It inserts brackets in different places in identical mathematical expressions to get different answers.
Put the brackets in grey cell. Using the results the Black Box shows you, correctly insert brackets into the mathematical expressions.
<table>
<tr><td>13</td><td>=</td><td>5</td><td>×</td><td>(</td><td>9</td><td>-</td><td></td><td>7</td><td>)</td><td>+</td><td>3</td><td></td></tr>
</table>
<table>
<tr><td>25</td><td>=</td><td>5</td><td>×</td><td>(</td><td>9</td><td>-</td><td></td><td>7</td><td></td><td>+</td><td>3</td><td>)</td></tr>
</table>
<table>
<tr><td>35</td><td>=</td><td>5</td><td>×</td><td></td><td>9</td><td>-</td><td>(</td><td>7</td><td></td><td>+</td><td>3</td><td>)</td></tr>
</table></td></tr>
</table>

6. Tasks Group “Rearrangement”

The idea behind rearrangement tasks is that their solutions require a clear order of actions limited by strict conditions. The tedious task of gradually moving objects teaches a child to think about consequences, analyse every action and build a strategy. It involves the transfer of objects from one position to another. Only the uppermost object is ever accessible. A rearrangement is only performed if the movement conforms to the conditions set regarding the size of the objects.

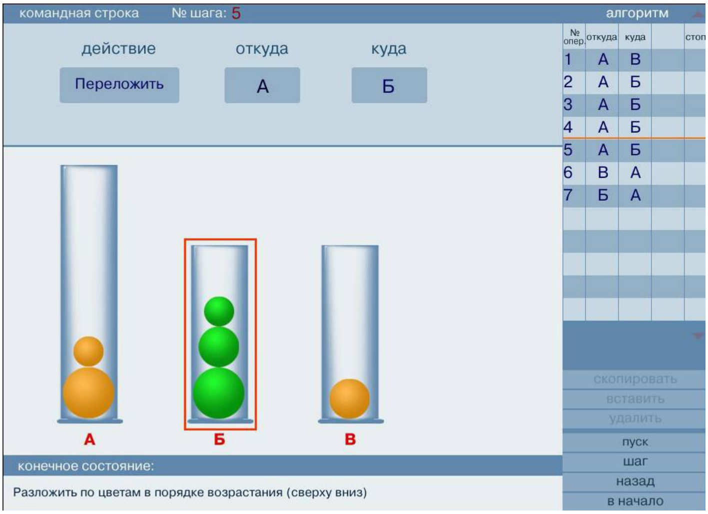

Fig. **6.** Example the screen for solution steps “Rearrangement”.

Typical ECL commands:

`< move > [A] , [B]`

Explanation:

`A` – tube (rod) to take,

`B` – tube (rod) to put.

Example task “Coloured balls 2”.

There are three test-tubes and three green, three red and three yellow balls (Fig. 7). The balls are stacked one upon the other in the first test-tube. The balls enter the test-tube one-by-one from the top. With the help of the other two test-tubes, arrange the balls by colour.

Representation of the solution as an algorithm:

```
start :                          7. < move > : [a] , [b]
1. < move > : [a] , [b]          8. < move > : [a] , [c]
2. < move > : [a] , [b]          9. < move > : [b] , [c]
3. < move > : [a] , [c]         10. < move > : [b] , [a]
4. < move > : [a] , [b]         11. < move > : [b] , [a]
5. < move > : [a] , [b]         12. < move > : [c] , [b]
6. < move > : [a] , [c]         end
```

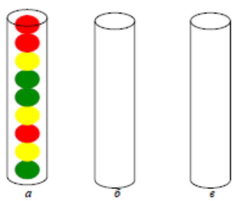

Fig. 7. Example task “Coloured balls 2”.

7. Tasks Group "Passings"

Passing tasks are about finding the optimal solution. Many things in the task can change: the motion trajectory, quantity, load-bearing capabilities and peculiarities of a raft, the quantity and quality of variable objects, the presence of additional conditions increasing the number of methods of solving them. In the proposed tasks there is a stack in the form of a ferry with an open entrance and open exit or a stack in the form of a barge with an open entrance and closed exit.

There is a spare stack or two stacks – a ferry or a barge in a river branch – with entrances and exits accordingly, but as this stack can stockpile a certain quantity of objects, we consider it unlimited in terms of objects stockpiled.

Several types of tasks can be provided for solving.

- **Type 1 tasks**. There are two piers situated on one bank. Traffic travels on a ferry from the source pier to the terminal pier. There is a spare ferry in the river branch.
- **Type 2 tasks**. There are three piers situated on one bank. Traffic travels on a ferry from the source pier to the terminal pier. There is a spare ferry in the river branch.
- **Type 3 tasks**. There are two piers situated on one bank. Traffic travels on a barge from the source pier to the terminal pier. There is a spare barge in the river branch.

Typical executor ECL commands:

`< load > : [n]`
`< cross > : [A] , [B] ([C])`
`< unload > : [n]`
(`n` is the number of a car in the queue).

Fig.8. Example the screen for solution steps "Passings".

Explanation:

`[A] , [B] ([C])` – designations of the banks and emergency stationary ferry on the river,

`n` – the number of the car.

Example task "Crossing 2: 5 cars".

A ferry travels from pier A to pier B, which are both situated on one side of the river. Using the ferry it is possible to transport one car at a time. The river also has a branch where a spare ferry *Z* is waiting. Cars can enter and exit both ferries from either side. Cars must be unloaded at pier *B* in a strict order: red – blue – white – red…. Cars are waiting for the ferry at pier *A* in a queue of this order: blue – red – blue – red – white… Transport 5 cars from pier *A* to pier *B* using the ferry and meeting the conditions. The cars are numbers 1 to 5.

Representation of the solution as an algorithm.

```
start:
 1. < load > : [1]
 2. < cross > : [A] , [Z]
 3. < unload > : [1]
 4. < cross > : [Z] , [A]
 5. < load > : [2]
 6. < cross > : [A] , [B]
 7. < unload > : [2]
 8. < cross > : [B] , [A]
 9. < load > : [3]
10. < cross > : [A] , [B]
11. < unload > : [3]
12. < cross > : [B] , [A]
13. < load > : [4]
14. < cross > : [A] , [Z]
15. < unload > : [4]
16. < cross > : [Z] , [A]
17. < load > : [5]
18. < cross > : [A] , [B]
19. < unload > : [5]
20. < cross > : [B] , [Z]
21. < load > : [4]
22. < cross > : [Z] , [B]
23. < unload > : [4]
24. < cross > : [B] , [Z]
25. < load > : [1]
26. < cross > : [Z] , [B]
27. < unload > : [1]
end
```

8. Conclusion

The virtual laboratory learning environment has a task editing plan for teachers, enabling them to edit their own tasks and use them in their chosen laboratory. Algorithmic problems are a part of informatics tuition at primary school (Tsvetkova and Kuris, 2008; Kuris and Tsvetkova, 2013) and form the basis for developing algorithmic thinking faculties in younger students. The concept the algorithmic problems Virtual Laboratories in Informatics as learning environment can be used for algorithm competitions and train to Olympiad for children interested in informatics at a school additional lessons (Kuris and Tsvetkova, 2013; Kiryukhin and Tsvetkova, 2014). It should be noted that these tasks are other examples of implementation: "Robotlandia" (ROBOTLANDIA, 2015), some tasks for students with grades 1–6 from the collection of the International contest in Informatics "Bebras" (Bebras, 2015).

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The ICT Competency MOOCs for Teachers in Russia

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Abstract. The experience of the formation of the framework of ICT competences for teachers on the basis by UNESCO Institute for Information Technologies in Education (IITE) research and dissemination of the experience of the MOOC in Russia for the development of ICT Competency teachers for digital education.

Keywords: digital education, massive open online course, ICT competency for teachers.

1. Introduction

The UNESCO Institute for Information Technologies in Education (IITE) (UNESCO, 2016a) was established as an integral part of UNESCO by the General Conference of UNESCO at its 29th Session (November 1997, Moscow, Russian Federation). At the same session, the Statutes of IITE were adopted.

According to its Statutes, the Institute contributes to the design and implementation of the programs of the Organization regarding the application of information and communication technologies in education. It is principally program-driven, responds to both global and country needs is a part of an operational network of UNESCO structures and supports the achievement of the strategic objectives of the Medium-Term Strategy as well as the program priorities of UNESCO, as approved by the General Conference.

IITE's mission is to serve as a center of excellence and provider of technical support and expertise in the area of ICT usage in education in the world.

The results of international analytical studies 2003–2013 published in the open access place in the electronic library IITE (UNESCO, 2016b), the countries of experience in the integration of new ICT into the education system regarding the information environment of globalization presented in the book "ICT in Education" (Badarch, 2013) (Fig. 1).

Fig. 1. The book “Information and Communication Technologies in Education”.

2. The ICT Competency Framework for Teachers: UNESCO ICT-CFT

One key lesson is to acknowledge the many facets that ICT in Education policies have to tackle such as teacher competencies, learning materials, ICT equipment, student and teacher motivation, as well as the linkages to other areas of national policy and socio-economic development. Adopting a cross-sectoral approach through an ICT in Education Master Plan help countries to address all relevant dimensions.

In this context, the ICT Competency Framework for Teachers is aimed at helping countries to develop comprehensive national teacher ICT competency policies and standards, and should be seen as an important component of an overall ICT in Education Master Plan.

The current version of the ICT Competency Framework for Teachers is a 2011 update of the original version published in 2008 and is the result of the partnership between UNESCO and CISCO, INTEL, ISTE, Microsoft. In this version, the Framework has been enriched on the basis by feedback from subject matter experts and users worldwide and enhanced with the inclusion of example syllabi and exam specifications for Technology Literacy and Knowledge Deepening (Midoro, 2013).

The ICT Competency Framework for Teachers (UNESCO ICT-CFT) were developed in 2008 and improved in 2011 by the UNESCO cross-sectoral working group based on consultations with experts in the field from all world regions. The aim of the Framework is to support the UNESCO Member States in developing national (regional) policy on teachers’ ICT competence and establishing the standards in this field. The Framework has been enriched using feedback from experts and users worldwide.

The Russian version of ICT-CFT was presented by the UNESCO Institute for Information Technologies in Education (IITE) in December 2011 (UNESCO, 2011).

Three approaches to human capacity development The Framework is based on the hypothesis that education can contribute to the development of a country's economy and society. The country can develop from one that uses ICTs (phase 1), to one that has a high-performance workforce (phase 2), and finally to one with a knowledge economy and information society (phase 3). These three phases serve as a basis for three complementary and somewhat overlapping approaches that connect education policy with economic development. The teachers' professional profile in ICTs develops following an analogous path: the professional levels are isomorphic to the national development goals, see table (Fig. 2).

3. Structure of UNESCO ICT-CFT

Six aspects of the teachers' activity/praxis The ICT-CFT assumes that there are six main aspects of the teacher's activity: understanding the ICT role, curriculum, pedagogy, ICTs, organization, and professional development. The framework of 18 modules reflects the

Development stages	Economy	Education	Approach
Capital Deepening: Use of ICTs	The ability of the workforce to use equipment that is more productive than earlier versions	Increase the extent to which new technology is used by students, citizens, and the workforce by incorporating technology skills into the school curriculum.	Technology literacy
Higher Quality Labour: High-performance workforce	A more knowledgeable workforce that is able to add value to economic output	Increase the ability of students, citizens, and the workforce to add value to society and the economy by using knowledge and applying it to solve complex, real-world problems	Knowledge deepening
Technological innovation: Knowledge economy and information society	The ability of the workforce to create, distribute, share, and use new knowledge.	Increase the ability of students, citizens, and the workforce to innovate, produce new knowledge, and benefit from this new knowledge.	Knowledge creation

Fig. 2. Matching of the UNESCO ICT-CFT approaches and stages of the socio-economical development of the society.

interrelation of the three approaches (technology literacy, knowledge deepening, knowledge creation) to teaching based on human capacity development with the six aspects of the teachers' work (understanding the ICT role, curriculum, ICTs, organization, and professional development) (see Fig. 3).

SECTION 1. PRELIMINARY QUESTIONS ON THE USE OF ICTS

1. What is your teaching position?
   a Kindergarten Teacher/ b. Lower Primary Teacher/ c. Upper Primary Teacher/ d. Primary Teacher Specialist (e.g., Music or Languages)/ e. Lower Secondary Teacher/ f. Secondary Teacher/ g. Special Education Teacher/ h. Other (specify)
2. What is your subject matter?
   a. Language/ b. Mathematics/ c. Science/ d. Society and Environment/ e. Physical Education/ f. Arts/ g. Technology/ h. Economics/ i. Language/ j. Other (specify).
3. How many years have you been working in schools?
   a. 0 to 1 year/ b. 2 to 3 years/ c. 4 to 5 years/ d. 6 to 9 years/ e. 10 to 19 years/ f. 20 years or more.
4. Is your school in a remote area?
   a. Yes/ b. No

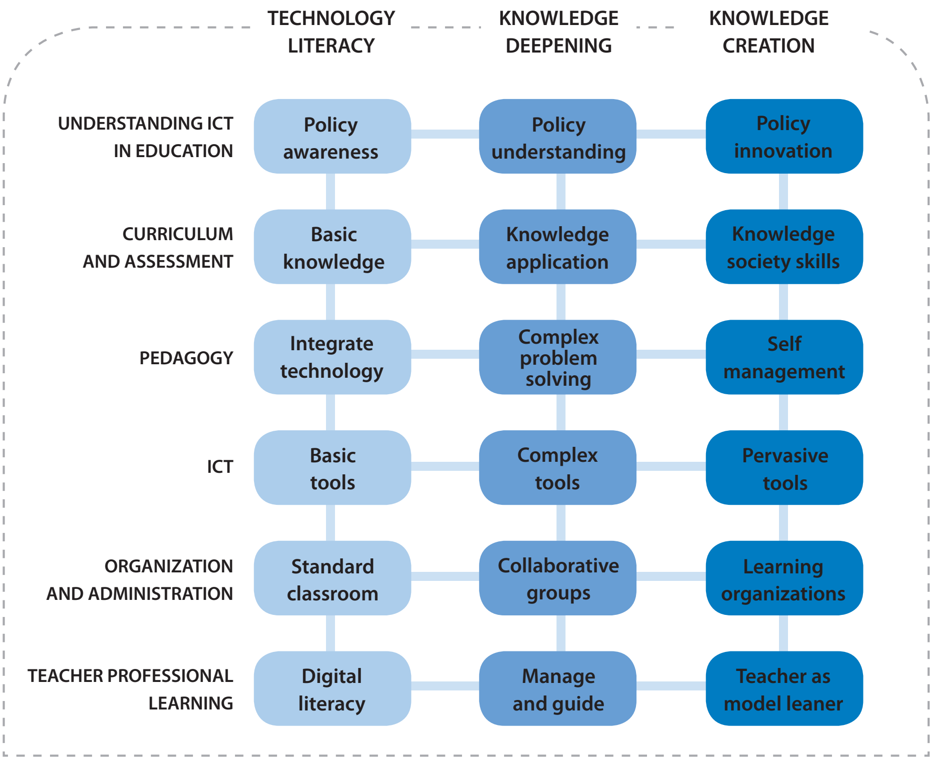

Fig. 3. Structure of UNESCO ICT-CFT.

5. What is your gender?
   a. Male/ b. Female
6. In which age group do you belong?
   a. Less than 24 years/ b. 25 to 29 years/ c. 30 to 39 years/ d. 40 to 49 years/ e. 50 to 64 years/ f. 65 years and over.
7. Can you use a computer?
   a. Yes/ b. No
8. How frequently do you use a computer?
   a. Daily/ b. Weekly/ c. Monthly/ d. At least once a term/ e. Never.
9. Do you have a computer at home?
   a. Yes/ b. No
10. Do you have an Internet access at home?
    a. Yes/ b. No
11. Can you use a computer at school?
    a. Yes/ b. No
12. Do you have an Internet access at school?
    a. Yes/ b. No
13. Are there other places where you can use a computer and access the Internet (Internet cafes, libraries, etc.)?
    a. Yes/ b. No

If the answer to question 7 is ”b” or the answer to question 8 is “e”, then the test is over.

4. Teachers ICT Competency

Otherwise, the teacher must complete Section 2 below. Section 2 has the same structure as the UNESCO ICT-CFT. The correctness of the answer to each item has to be determined by local experts once the questionnaire is localized since its validity could depend on local conditions.

Each question provides only select one answer.

SECTION 2.

UNIT 1. “TECHNOLOGY LITERACY”

1.1. UNDERSTANDING ICTS IN EDUCATION: POLICY AWARENESS

1. Is there a policy for introducing ICT in the school in your country?
   a. Yes/ b. No/ c. I don’t know
2. If the answer to question 1 is Yes, this policy is at:
   a. National level/ b. Regional level/ c. School level/ d. I don’t know
3. Would you be able to describe how this policy is implemented in your school?
   a. Yes/ b. No/ c. I don’t know

4. Would you be able to describe the positive aspects and weaknesses?
   a. Yes/ b. No/ c. I don't know
5. Indicate the extent to which you agree or disagree with each statement about ICTs:
   a. Students' use of ICTs can support student-centered learning
      (strongly agree, 1, 2, 3, 4, 5, strongly disagree)/
   b. ICTs provide valuable resources and tools to support student learning
      (strongly agree, 1, 2, 3, 4, 5, strongly disagree)/
   c. ICTs can be mainly used for efficient presentations
      (strongly agree, 1, 2, 3, 4, 5, strongly disagree)/
   d. ICTs has limited capacity to provide benefits in the classroom
      (strongly agree, 1, 2, 3, 4, 5, strongly disagree)

1.2. CURRICULUM AND ASSESSMENT: BASIC KNOWLEDGE

1. To what extent do you use ICTs with your students in the context of your discipline?
   (no, 1, 2, 3, 4, 5, large)
2. Have you ever used educational software related to your subject matter?
   a. Yes/ b. No
3. To what extent do you use educational software related to your subject matter with your students?
   (no, 1, 2, 3, 4, 5, large)
4. To what extent do you use digital artifacts from student assignments as evidence of student achievement?
   (no, 1, 2, 3, 4, 5, large)
5. 5. To what extent do you use ICT applications to monitor, evaluate, and report on student achievement?
   (no, 1, 2, 3, 4, 5, large)

1.3. PEDAGOGY: INTEGRATE TECHNOLOGY

1. To what extent do you use presentation software in your lessons?
   (no, 1, 2, 3, 4, 5, large)
2. Do your students use ICTs for mastering skills just taught?
   a. Yes/ b. No
3. To what extent do you use digital resources in your lessons?
   (no, 1, 2, 3, 4, 5, large)
4. Do you design lesson plans incorporating digital resources?
   a. Yes/ b. No
5. To what extent do you share your experience of ICT use with other teachers?
   (no, 1, 2, 3, 4, 5, large)

1.4. ICTS: BASIC TOOLS

1. To what extent do you use a word processor?
   (no, 1, 2, 3, 4, 5, large)
2. To what extent do you use presentation software?

(no, 1, 2, 3, 4, 5, large)

3. To what extent do you use a web browser?
   (no, 1, 2, 3, 4, 5, large)
4. To what extent do you use a search engine?
   (no, 1, 2, 3, 4, 5, large)
5. To what extent do you use an email address?
   (no, 1, 2, 3, 4, 5, large)
6. To what extent do you use some course?
   (no, 1, 2, 3, 4, 5, large)
7. To what extent do you use open educational resources?
   (no, 1, 2, 3, 4, 5, large)
8. Do you use the computer to record grades, maintain student records, or to take students' attendance?
   a. Yes/ b. No

1.5. ORGANISATION AND ADMINISTRATION: STANDARD CLASSROOM

1. To what extent do you integrate the use of a computer lab in the teaching activities?
   (no, 1, 2, 3, 4, 5, large)
2. To what extent do you use ICTs in the classroom?
   (no, 1, 2, 3, 4, 5, large)
3. To what extent do you use ICTs with your students for presentations, without altering the classroom setting?
   (no, 1, 2, 3, 4, 5, large)
4. To what extent do you use ICTs in the classroom for individual study?
   (no, 1, 2, 3, 4, 5, large)
5. To what extent do you use ICTs in the classroom for small group activities?
   (no, 1, 2, 3, 4, 5, large)

1.6. TEACHER PROFESSIONAL LEARNING: DIGITAL LITERACY

1. To what extent do you use digital resources to enhance your school productivity?
   (no, 1, 2, 3, 4, 5, large)
2. To what extent do you use digital resources to learn about your subject matter?
   (no, 1, 2, 3, 4, 5, large)
3. Have you ever used ICTs to access online courses?
   a. Yes/ b. No
4. Could you list at least three of the main Internet issues related to ethics?
   a. Yes/ b. No

UNIT 2. "KNOWLEDGE DEEPENING"

2.1. UNDERSTANDING ICT IN EDUCATION: POLICY UNDERSTANDING

1. To what extent do you think that ICTs could change the school?
   a. (no, 1, 2, 3, 4, 5, large)/ b. I have no precise idea

2. To what extent do you credit policy for introducing ICTs in the school in your country?
   a. (no, 1, 2, 3, 4, 5, large)/ b. I have no precise idea
3. To what extent has this policy changed your practice in the classroom?
   a. (no, 1, 2, 3, 4, 5, large)/ b. I have no precise idea

2.2. CURRICULUM AND ASSESSMENT: KNOWLEDGE APPLICATION

1. To what extent do you use ICTs with your students to understand real-world problems?
   (no, 1, 2, 3, 4, 5, large)
2. Have you ever used web 2.0 for learning assessment?
   a. Yes/ b. No/ c. I do not fully understand the question
3. To what extent do you use innovative ways of assessment using ICTs?
   a. (no, 1, 2, 3, 4, 5, large)/ b. I do not fully understand the question
4. To what extent do you help students apply knowledge obtained in your class in real-world situations?
   (no, 1, 2, 3, 4, 5, large)

2.3. PEDAGOGY: COMPLEX PROBLEM SOLVING

1. To what extent do you adopt collaborative learning in the classroom?
   (no, 1, 2, 3, 4, 5, large)
2. To what extent do you adopt project-based learning in the classroom?
   (no, 1, 2, 3, 4, 5, large)
3. To what extent do you design online materials for supporting your students?
   (no, 1, 2, 3, 4, 5, large)
4. To what extent do you deal with real-world problems in project-based learning?
   (no, 1, 2, 3, 4, 5, large)

2.4. ICTS: COMPLEX TOOLS

1. To what extent do you use authoring environments to produce learning material for your students?
   (no, 1, 2, 3, 4, 5, large)
2. To what extent do you use authoring environments to produce online material for your students?
   (no, 1, 2, 3, 4, 5, large)
3. Do you use a platform to manage, monitor, or assess the progress of your students?
   a. Yes/ b. No
4. To what extent do you use ICTs to communicate with your students?
   (no, 1, 2, 3, 4, 5, large)
5. Do you use a platform to support your students' learning?
   a. Yes/ b. No
6. Do you use social networks to interact with your students and colleagues?
   a. Yes/ b. No

7. To what extent do you use open educational resources?
   (no, 1, 2, 3, 4, 5, large)
8. Do you use ICTs to collaborate with other schools?
   a. Yes/ b. No

2.5. ORGANISATION AND ADMINISTRATION: COLLABORATIVE GROUPS

1. Do you organize computers and other resources within the classroom to support collaborative activities?
   a. Yes/ b. No
2. Do you create a learning environment to manage project-based activities?
   a. Yes/ b. No
3. Do you organize the classroom to support groups working with different tools?
   a. Yes/ b. No
4. To what extent can you define the requirements of a classroom setting to match the needs of groups working collaboratively?
   (no, 1, 2, 3, 4, 5, large)

2.6. TEACHER PROFESSIONAL LEARNING: MANAGE AND GUIDE

1. Do you share digital resources with you colleagues?
   a. Yes/ b. No
2. Do you collaborate with outside experts?
   a. Yes/ b. No
3. Are you a member of a teachers' virtual community of practice?
   a. Yes/ b. No
4. To what extent do you use the Internet for your professional learning?
   (no, 1, 2, 3, 4, 5, large)

UNIT 3. "KNOWLEDGE CREATION"

3.1. UNDERSTANDING ICTS IN EDUCATION: POLICY INNOVATION

1. How do you think that you could contribute to implement or modify an ICT policy in the school?
   a. (very little, 1, 2, 3, 4, 5, radically)/ b. I have no precise idea
2. How do yo contribute to the discussion of policy for introducing ICTs in the school?
   a. (very little, 1, 2, 3, 4, 5, radically)/ b. I have no precise idea
3. How did this policy to change your practice in the classroom?
   a. (very little, 1, 2, 3, 4, 5, radically)/ b. I have no precise idea

3.2. CURRICULUM AND ASSESSMENT: KNOWLEDGE SOCIETY SKILLS

1. Do you intentionally use ICTs to improve students' communication skills?
   a. Yes/ b. No
2. Do you intentionally use ICTs to help students find ideas and information?
   a. Yes/ b. No

3. Do you intentionally use ICTs to help students to collaborate?
   a. Yes/ b. No
4. Do you intentionally use ICTs to help students share knowledge?
   a. Yes/ b. No
5. Do you help students acquire information problem-solving skills?
   a. Yes/ b. No/ c. The question is not clear to me
6. Do you use web 2.0 to assess higher order skills (creativity, problem solving, collaboration, etc.)?
   a. Yes/ b. No/ c. The question is not clear to me

3.3. PEDAGOGY: SELF-MANAGEMENT

1. Do you design online activities that engage students in problem-solving or artistic creation?
   a. Yes/ b. No
2. Do you help students in multimedia production?
   a. (very little, 1, 2, 3, 4, 5, very much)
3. How important is the creation of students' new knowledge?
   a. (very little, 1, 2, 3, 4, 5, very much)
4. Do you reflect with your students on their own learning?
   a. (very little, 1, 2, 3, 4, 5, very much)

3.4. ICTS: PERVASIVE TECHNOLOGY

1. Do you design online learning environments to support your students' learning?
   a. Yes/ b. No
2. Do you use social networks to support your students' learning?
   a. Yes/ b. No
3. Do you use web 2.0 to support students' in creating their own digital products?
   a. Yes/ b. No/ c. The question is not clear to me
4. Is your classroom involved in learning projects with other schools using online communication?
   a. Yes/ b. No

3.5. ORGANISATION AND ADMINISTRATION: LEARNING ORGANIZATIONS

1. Do you organize the classroom as a learning community?
   a. Yes/ b. No
2. Do you create a learning environment to support collaborative projects with other schools?
   a. Yes/ b. No
3. Do you use the web to collaborate with your colleagues systematically?
   a. Yes/ b. No
4. Do you share your materials and projects with other teachers?
   a. Yes/ b. No

3.6. TEACHER PROFESSIONAL LEARNING: TEACHER AS A MODEL LEARNER

1. Do you play a key role in introducing ICTs into your school?
   a. Yes/ b. No
2. Do you are considered a leader in introducing ICTs in Education?
   a. Yes/ b. No
3. Do your colleagues consult with you to introduce ICTs in their own teaching?
   a. Yes/ b. No
4. Do you teach in teachers' in-service courses?
   a. Yes/ b. No
5. Do you participate in professional virtual communities?
   a. Yes/ b. No

5. Digital Education: MOOC Platform in RuNet

Fast development and diffusion of information and communication technologies (ICT) have had a significant impact on the change of the traditional model of educational systems and teaching and learning methods. The development of distance education technologies and employment of digital education content expand the access to higher education and contribute to the improvement of its quality, which is particularly important for developing countries. Massive Open Online Courses (MOOC), recognized as one of 30 the most promising trends in education until 2028 among, opened up new possibilities in the field of distance education.

Russian-speaking MOOC on Coursera (Coursera) – an educational platform that offers free online courses: the partners include leading universities and organizations around the world (Coursera, 2016).

Electronic courses IITE UNESCO (UNESCO, 2016c) – open courses portal in Russian and English languages: the course "ICT in education" (in Russian) for teachers of the Russian language space is created on the basis by the same study (books materials).

National Open University – INTUIT (INTUIT, 2016):

- Courses (total: 548).
- Video courses (total: 174).
- Certification (total: 57).
- Intel Academy (total: 20).
- Microsoft Academy (total: 101).

Courses in IT:

- Algorithms and discrete structures.
- Hardware.
- Database.
- Security.

- Graphic and Design.
- Internet technologies.
- Artificial Intelligence and Robotics.
- Computer graphics.
- Mobile technology.
- OS.
- Office technology.
- Programming.
- Software.
- CAD.
- Network technologies.
- Supercomputer technologies.

Universarium – inter-university e-learning platform (Universarium, 2016): open Online Courses Russian universities.

Lectorium – educational project (Lektorium, 2016): open Video Courses University Teachers.

Rusere – Russian-language electronic resources in education (RUSERE, 2016): courses ICT competence of teachers.

6. Digital Education: MOOC for Teachers

Since September 2014 IITE shoves in MOOC work "ICT in Education" for mass self-education teachers in Russia of the ICT competence.

The core of the course is the book "ICT in Education", published 2013. The book is presented in electronic library of the UNESCO IITE in the public domain and is made in the form of a platform «e-book» (UNESCO, 2016d). The electronic textbook integrated hyperlinks to all the important e-books from UNESCO IITE electronic library and open online courses IITE. The electronic textbook "ICT in education" provided with questions to the topics, practical tasks for independent work of a web user.

For Russian teachers deployed portal (RUSERE, 2016) as an open resource in domain RU. This portal is the medium for cooperation in the design of the course "ICT in Education" various regional training centers proposed a single program. The program provides a sample matrix of online course design, using different models of his presentation: a model of a distance course IITE, model «e-book» and model on Web3.0 portal (RUSERE, 2016; ACADEMIA, 2016).

A total of presented three MOOC for teachers (RUSERE, 2016):

- **Electronic textbook in information-educational space of school.** The goal of the course – to obtain new professional competencies of teachers needed for the activity in the information-educational space of the school, the formation skills of teachers to use e-books in lessons.

- **New ICT competence of teachers.** The goal of the course – the formation of the total for all of the readiness of teachers to integrate learning technologies on the basis by ICT resources in teaching practice.
- **Construction masks on an open platform Open edX.** The course is designed to train teachers design their open training online modules for students on the topics on the subject of the program. Upon completion of training, the teacher to create copyrights online courses on an open platform Open edX and provide an opportunity for students to develop remotely additional modules on the program of the subject matter.

7. Conclusion

The methodological approach proposed in this document explains the stages of the UNESCO ICT-CFT adaptation process; suggests guidelines to determine the appropriate strategies and policies for the development of ICTs in education, and identifies the resources needed for the successful implementation of the ICT-CFT to the local context.

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For contribution to collective works:

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