Informatics Education based on Solving Attractive Tasks through a Contest

Valentina Dagiene[1], **Gabriele Stupuriene**[2]
Faculty of Mathematics and Informatics
Vilnius University
[1]Naugarduko str. 24
LT-03225, Vilnius
valentina.dagiene@mii.vu.lt
[2]Akademijos str. 4
LT-08663 Vilnius
gabriele.stupuriene@mii.vu.lt

Abstract: The paper discusses the issue of supporting informatics (computer science) education through competitions for lower and upper secondary school students (8–19 years old). Competitions play an important role for learners as a source of inspiration, innovation, and attraction. Running contests in informatics for school students for many years, we have noticed that the students consider the contest experience very engaging and exciting as well as a learning experience. A contest is an excellent instrument to involve students in problem solving activities. An overview of infrastructure and development of an informatics contest from international level to the national one (the *Bebras* contest on informatics and computer fluency, originated in Lithuania) is presented. The performance of *Bebras* contests in 23 countries during the last 10 years showed an unexpected and unusually high acceptance by school students and teachers. Many thousands of students participated and got a valuable input in addition to their regular informatics lectures at school. In the paper, the main attention is paid to the developed tasks and analysis of students' task solving results in Lithuania.

Keywords: Informatics Education, Computer Science Education, Tasks, Tests, Contest, Problem Solving, Cognitive Skills, Bloom's Taxonomy

1 Introduction

Competition makes teaching of informatics (computer science, computing) more attractive for children. During contests students have the possibility to test their skills among peers from different schools or even countries and to make friends in a field that they have interests. The contest on informatics and computer fluency named *'Bebras'* (it is a Lithuanian word for 'beaver') may be the key to the potential of informatics science knowledge and an attractive way to bind up technology and education.

Bebras is an international initiative whose goal is to promote informatics and computational thinking especially among teachers and students of all ages, but also to the public at large. The big challenge of *Bebras* is to organise easily accessible and highly motivating online contests in many countries. The contest was established in 2004 by Lithuanian suggestion (Dagiene, 2006). It is involving massively growing numbers of students and countries. Lithuania celebrated its 10th year's anniversary of running the *Bebras* contest in November last year. Since 2004, the *Bebras* contest has quickly spread across Europe and now is a really international motion. Overall, more than 0.7 million students participated in the Bebras contest in 2013 (Table 1).

The *Bebras* contest is design to promote informatics fundamentals for both boys and girls and equally attract their attention. The result is quite good: quite a big number of girls have taken part in last year's contest; some countries even have equal or almost equal participants of both genders (Italy, Japan, Taiwan, see Table 1).

Table 1: Numbers of participants distrusted by country and gender in 2013 contest

Country	Total	Girls	Boys
Austria	**12 154**		
Belgium	**848**		
Bulgaria	**551**	188	636
Canada	**4 229**		
Czech R.	**34 454**	15 386	19 068
Estonia	**3 517**		
Finland	**4 423**	1 846	2 577
France	**171 932**		
Germany	**206 430**		
Hungary	**6 246**		
Ireland	**3 141**	1 375	1 470
Italy	**3 288**	1 644	1 644
Israel	**~2000**		
Japan	**4 371**	2 082	2 289
Latvia	**1 038**	434	604
Lithuania	**25 909**	10 817	15 092
The Netherlands	**12 592**		
New Zealand	**217**		
Poland	**15 933**	11 534	4 399
R. of South Africa	**1 111**		
Russian F.	**17 584**	8 203	9 381
Slovakia	**55 017**	24 217	30 800
Slovenia	**12 040**	5 152	6. 36
Spain	**711**		
Sweden	**1 869**	695	1 446
Switzerland	**9 832**		
Taiwan	**9 526**	4 842	4 684
Ukraine	**86 266**	41 077	45 189
United Kingdom	**21 473**		

In Lithuania, similarly to other participating countries, we strive to implement the contest as a nationwide and efficient event for sending the message about informatics to students and teachers. Under agreements of the involved countries, the second week of November is announced as a *Bebras* week each year.

The contests are made of a set of short questions or tests usually called *Bebras* tasks. These tasks can be answered without prior knowledge about informatics, but are clearly related to fundamental informatics concepts. To solve those tasks, students are required to think in and about information, discrete structures, computation, data processing, data visualisation, but they also must use algorithmic as well as programming concepts. Each *Bebras* task can both demonstrate an aspect of informatics and test the talent of the participant, regarding understanding of informatics.

The *Bebras* initiative is based on two main events: 1) an international workshop which takes place between May and June and is organised in order to discuss the task set for the coming contest; and 2) national contests organised in all participating countries in autumn during the *Bebras* week. Additional activities take place around those two main events. Many countries run a second round for the *Bebras* contest, some countries organise *Bebras*-tasks training workshops for teachers or summer camps for students. Many more activities are set within countries all through the year: participants' awarding celebration, seminars about Informatics concepts, collecting data and writing research papers, etc.

The main aim of the paper is to give a general overview of students' performance in the *Bebras* contest of 2013 in Lithuania and discuss how students (including primary) and upper secondary education cope with it.

2 Contest as a Promoter of Informatics Education

The *Bebras* contest is organised by each participating country locally (Dagiene, Futschek, 2008). Usually there are national committees or organisations established which aim to run the *Bebras* contest. For running the contest, countries are using different technologies mainly based on online contest management systems.

Each country chooses tasks from a *Bebras* task pool approved by the annually organised international *Bebras* task workshop. There are however some mandatory tasks that all countries are obliged to use. There are different task sets for different age students. Five age groups have been used (Table 2).

Table 2: Age groups

Groupe name	Grade, age	Comments
Mini (Little Beavers)	3 and 4, age 8–10	Only few countries have this group: Czech Republic, Finland, Lithuania, Poland, Slovakia, Sweden
Benjamin	5 and 6, age 11–12	Some countries have merged Benjamins and Cadets
Cadet	7 and 8, age 13–14	
Junior	9 and 10, age 15–16	
Senior	11 and 12, age 17–19	Some countries have grade 13 as well

Some countries have been using slightly different distributions of groups. For example, Estonia has run the contest in three age groups: grades 6, 7, and 8 are used for cadets, 9 and 10 for juniors and the rest for seniors. In Lithuania we have all five age groups as it is shown in Table 2. Most participants are from grades 5 to 9, the other grades have a lower number of participants (Fig. 1).

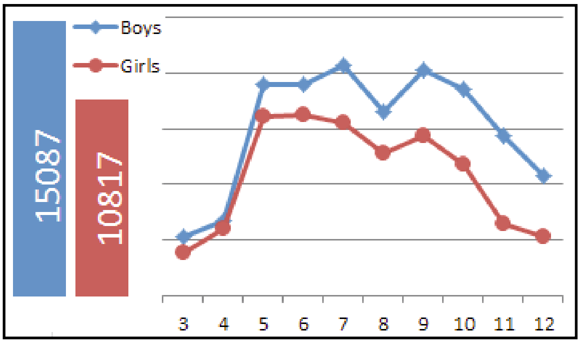


Figure 1: Numbers of contestants distributed by grades (from 3rd to 12th) in Lithuania in 2013

Running contests, however, is used essentially to attract students and teachers. The fundamental goals are to promote informatics as a science among youth, to show how fascinating it is, to think about and to solve informatics problems, and to demonstrate that, on principle, informatics is approachable by everyone. The central tools to achieve these goals are the *Bebras* tasks. Not only are they used in the contests, but also spread among teachers in order to provide them with a wealth of teaching items that can flexibly be incorporated in informatics lessons, school-wide informatics promotional activities or any other occasion to show the attraction of informatics in an entertaining way.

The *Bebras* contest essentially focuses on informatics concepts. Understanding and handling the basics and foundations of informatics is more important than knowing technical details. The use and interpretation of results comes prior to being able to prove results. Controlling computations, calculations and estimations is more significant than being able to do computations by ourselves. A computer has to be understood at many levels, including: as a fundamental culture item and not as a collection of buttons and instructions; as a development of ideas and not a finished work; as an explanation of the concepts, etc. All these topics we keep in mind while organizing contests and working on task preparation.

The informatics curricula in Lithuanian lower and upper secondary schools, the evaluation schemes and even the denominations have been changed; nevertheless Informatics has remained a separate subject, now called "information technologies (IT)". Besides, one of the most important components of IT is to make students of comprehensive schools digitally literate. In Lithuanian lower secondary schools the IT courses are compulsory for the 5th–10th grades (student age 12–17 years) for approximately 1 hour per week, respectively 35 hours per year. There are some optional modules as well (e.g. a programming module in grade 9 or 10). Students of upper secondary schools (11th and 12th grades) can choose advanced optional modules and have to learn the content defined in the course curriculum.

However, there is no common international agreement on an accepted framework for informatics and information technologies courses in general education, although there are several discussions on this issue (Dagiene, Futschek, 2010; Micheuz, 2008; Hromkovic, 2006; Micheuz, 2005; Schubert, 2004). However a number of key concepts arise repeatedly in informatics: languages, machines, and computation; data and representation; communication and coordination; abstraction and design; the wider context of computers (Computing at School Working Group, 2012).

Almost a common opinion is that fundamentals of algorithms and programming are the key concepts in school informatics education. Then, what concepts should we include in informatics education apart from algorithms and programming? What is the ratio of programming concepts and information technology concepts and their application?

The basic concepts of informatics are mentioned in many scientific papers but they are not well defined or commonly accepted. There exist attempts to define the more powerful term "fundamental idea" as an educational principle. Fundamental ideas fulfil the four criteria of the paper (Schwill, 1997):

- Horizontal criterion (applicable in multiple ways in different areas)
- Vertical criterion (may be learned on every intellectual level)
- Criterion of time (observable in the historical development and will be relevant in the longer term)
- Criterion of sense (meaning in everyday life and related to ordinary language)

A. Schwill identified three fundamental master ideas within the software development life cycle: algorithmization, structured dissection and language. In the context of our contest we use the term concept of informatics since we can involve in our short tasks only aspects of fundamental ideas. But we have the four criteria for fundamental ideas in mind to create tasks that involve concepts that are hopefully interesting for a long term, can also be understood without too much pre-knowledge, can be used also in other areas and can be understood at different intellectual levels.

3 Bebras Tasks for Transmission of Informatics Concept to Learners

Interesting, attractive tasks on informatics concepts are crucial for *Bebras* contests. About 200 new challenging tasks are needed each year. Teachers should learn how to explain what is behind one or another *Bebras* task. Also teachers should learn how to develop *Bebras* tasks. So for workshops and conferences the target groups are teachers.

Each countrywide contest is a collection of small, interesting questions that can be answered without prior knowledge about informatics, but are clearly related to informatics concepts and require thinking in and about informational, discrete structures as well as algorithmic, programming concepts.

The key idea behind each task presented to contestants is not to ask for already learned facts but to give problems that allow students to learn something about concepts (on informatics, computer science, computing) that may be new for them.

Every year, new *Bebras* tasks are developed in a cooperative effort of all countries involved: the *Bebras* international Task Workshop. Each country provides a set of task proposals, and the whole pool of proposals is then discussed at the annual International Task Workshop. There, proposals may be rejected, refined, or simply accepted for use in that year's *Bebras* contests. A task pool is the result of this workshop. The national organisers make up their national task set from this pool. However, at the workshop, a subset of the task pool, which has been growing over the years, is determined to be "mandatory" and hence is used in all national *Bebras* contests.

When preparing for the actual year of the contest we drew on the characteristics of appropriate tasks from (Dagiene, Futschek, 2008). To be able to deeply analyse students' solutions and properly interpret resulting observations, we have developed the following six task types:

- ***Information***: conception of information, its representation (symbolic, numerical, graphical), encoding, encrypting;
- ***Algorithms***: action formalization, action description according to certain rules;
- ***Computer systems and their application***: interaction of computer components, development, common principles of program functionality, search engines, etc.;
- ***Structures and patterns***: components of discrete mathematics, elements of combinatorics and actions with them;
- ***Social effect of technologies***: cognitive, legal, ethical, cultural, integral aspects of information and communication technologies;
- ***Informatics and information technology puzzles***: logical games, mind maps, used to develop technology-based skills.

The descriptions of these task types also involve concepts of informatics although this was not the goal of this classification. It gives anyway a rough idea what kinds of problems and what topics of computer science we have in mind for *Bebras* contests.

In the short *Bebras* tasks we can include concepts of informatics like algorithms and programs: sequential and concurrent; data structures like heaps, stacks and queues; modelling of states, control flow and data flow; human-computer interaction; graphics; etc. Using a proper problem statement nearly all aspects of computer science and ICT can be a topic of a *Bebras* task.

While analysing students' solutions of the Slovakian contest in 2009, Kalas and Tomcsanyiova have proposed a new categorization of tasks into four components of informatics education (Kalas, 2009):

1. **Digital literacy**
   - Basic knowledge and concepts of informatics and computers
   - Computer literacy, working with applications
   - Ethical and legal issues, security, history of computing and informatics
2. **Programming**
   - Formal description of a solution, process, behaviour, progress
   - Understanding, analysing, interpretation and assembling such descriptions
   - Algorithms, algorithmic thinking
3. **Problem solving**
   - Logical reasoning, justification, argumentation
   - Puzzles, riddles, problems
   - Strategies for problem solving
4. **Data handling**
   - Representations, coding, patterns, structures
   - Mathematical basics of informatics, combinatorics
   - Data and data structures, information and data processing

The quality of tasks is crucial for the success of all task-based competitions. The tasks must reflect the goals of the competition and should be adequate to the applicants. In educational competitions, the tasks should attract students and drive them to learn and explore as well as to develop skills in the particular area.

When teaching informatics through problem solving, it is very important to choose interesting tasks. Therefore, one should try to present problems from various areas of science and life, with a lot of data. Processing large amounts of data becomes one of the most important aspects when learning programming.

The cognitive domain involves knowledge and the development of intellectual skills (Bloom, 1956). This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. There are six major categories, starting from the simplest behaviour to the most complex. The categories can be thought of as degrees of difficulty.

Let us analyse a task set used in the *Bebras* contest last year in regard to the informatics concepts. Each task is characterised by main informatics concepts, which are included with the aim to bring them to the students (see Annex I). We have classified what kind of cognitive skills must be applied by students for solving each *Bebras* task. Task classification is based on Bloom's revised categories (Anderson et al., 2000) and on Kalas' developed schema

(Kalas, 2009). We label tasks using a first letter according to age groups: M for Mini (Primary), B for Benjamins, C for Cadets, J for Juniors, and S for Seniors. Some tasks were used in more than one age group; these tasks have several letters. *Bebras* tasks are spread in all revised Bloom's categories; most tasks are in domains of Understanding, Applying, Analysing and Evaluating (Table 3).

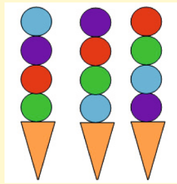
Table 3: Classification of tasks used in Lithuanian Bebras contest 2013

Cognitive skills applied	**Tasks**
Remembering general facts, basic concepts	M2; B7
Understanding (simple) given language and commands, comprehending the meaning	M11+B5; B12+C5; M3; M4; J12
Understanding (complex) description of processes, rules of behaviour and methods	M6+B2; M17; B6; C11; M7; B11; B15; J11; S14; S21
Applying given generative rule(s) or method(s) to an initial state, input or situation	1; M5+B1; B17; C12+J3; C14+J5; C21+J15; B9; M13; M18+C4; B21+S8; S20
Applying – interpret given instructions or program	M10+B4; B19+C9; C19+J9; J21+S13; M14; B14; J17+S15; S7; S17
Analysing situation and processes	M9+B3+C2; J13+S5; J19+S11; B10; S6
Analysing – matching several descriptions with several behaviours	M12+B8+C3; C15; J18+S10; M16; C6; C17+J6; S18
Evaluating – comparing different situations or solutions by certain criterion	C20+J10+S4
Evaluating – deducing possible result, final state or final product	M8+C1; B16; B20+C10+J8+S2; C7+J2; C13+J4; J16; J20+S12; B13+C8+J1+S1; C16; S16; S19
Creating - compiling information together	B18; J14+S9; M15; C18+J7+S3

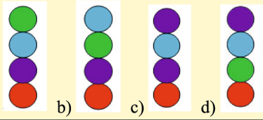
So that the reader could better understand our conception of informatics education and also the analysis of the tasks offered in the Annex, herein we present complete wordings of three tasks. The first of them fits into programming and was solved by both Mini and Benjamin groups; the second one belongs to data handling and operation abstraction and was mandatory for all age groups except the youngest (Mini); the third one was assigned to Juniors and Seniors and focuses on top-down analysis.

Task 1: Ice cream machine

The ice cream machine always put scoops in the same order. In the picture (on the right), you can see three examples for it:



Which order could come from the machine?



a) b) c) d)

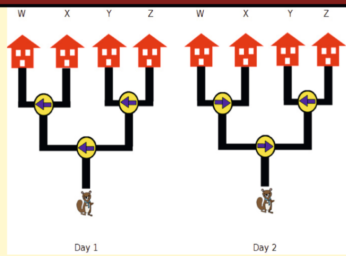
Task 2: Spinning toy

Beavers discovered a piece of wood into which worms had made a system of tunnels and pits. A handy father used it to make a toy.
To start we put a marble in the middle. The goal is to get the marble out by turning the wheel to the left (L) and right (R). By each turn the marble either runs to the next pit or (at the end) out of the wheel.

By which of the following sequences will the marble reach the exit?
a) LRRLR b) RLRLL c) LRRLRL d) LRRRRL

Task 3: Visiting friends

Mr. Beaver has 4 friends living in different villages, and he plans to visit one of these friends every afternoon. Initially, all arrows point to the left road. When passing the intersection, Mr. Beaver would switch the arrow to the opposite direction. For example, on day 1, Mr. Beaver takes the road on the left at the first intersection, takes the left road on the second intersection, and reaches Village W. On day 2, Mr. Beaver turns right at the first intersection, then left at the second intersection, and he arrives in Village Y.



Which village will Mr. Beaver visit on day 30?
a) Village W b) Village X c) Village Y d) Village Z

Figure 2: Three task examples taken from the *Bebras* contest 2013

4 Analysing Solutions of Contestans

We have studied the differences among the informatics tasks at the level of cognitive skills, which students had to apply while solving them. We will show the results of different age and gender groups. We analysed the data, which we obtained before and during the contest. We recorded which tasks were solved by each student and which of four given choices they indicated as correct.

Last year 25909 students took part in the contest in Lithuania, out of them 2176 Mini, 7022 Benjamins, 6550 Cadets, 6490 Juniors, and 3671 Seniors. Figure 4 shows total numbers of boys and girls in these age groups, together with the distributions of their total scores. Horizontal axis represents all possible scores (between 0 and 90 for Mini group, and between 0 and 105 for all others); vertical axis represents numbers of boys and girls who got corresponding score.

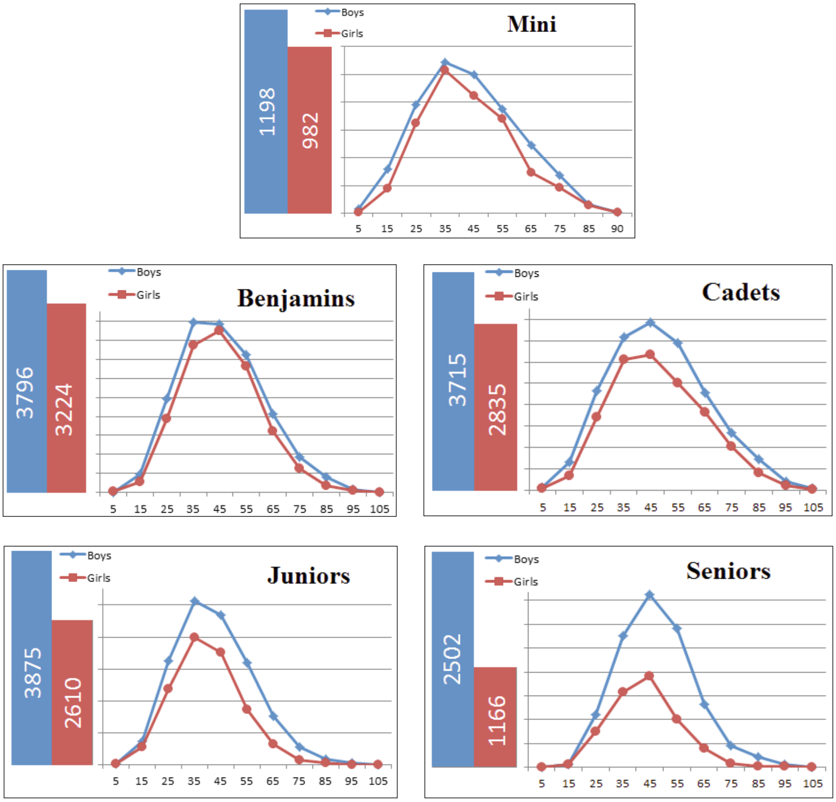


Figure 3: How successful were boys and girls when solving tasks – the distributions of their scores in all five age groups

We consider the total scores excellent: 62.35 % of contestants got more than 1/3 of the points; 22.92 % of contestants got more than half of the points; 5 % got more than 2/3 of the points; 0.33 % got more than 90 points (or 80 for the Mini group). This proves that the main goal of the event was accomplished – to provide an attractive opportunity to deliver informatics education to a group of students as wide as possible, without any preference of any particular group(s).

Attendance of the girls in these two categories significantly exceeded our expectations. As we can see from the charts the girls of all groups except

Senior are doing very well with minimal difference between boys and girls. In our opinion these results disprove the misconception that informatics is a boyish subject.

Figures 5 and 6 show the dependency of the number of correct and incorrect solutions (separately for boys and girls) on student age for tasks presented in section 3.

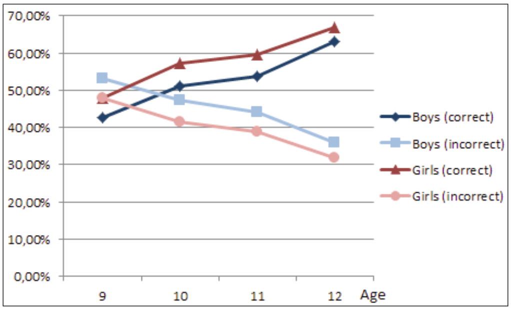
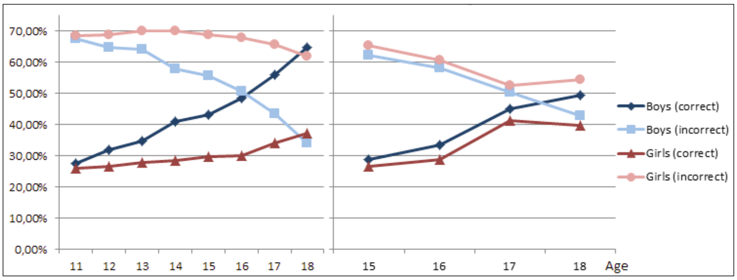


Figure 4: Distribution of solution of the task “Ice cream machine”



Figures 5: Distribution of solutions of the tasks “Spinning toy” (left) and “Visiting friends” (right)

Figure 5 shows that girls of the ages 9 to 12 did slightly better than boys for the task “Ice cream machine”, their scores are better and there are less wrong answers (guessing). However the task “Spinning toy” was exceptionally hard for girls of all ages from 11 to 18. Why? This task requires deep abstract thinking and imagination. Abstraction is one of the main three components of computational thinking. Our schools should focus more on developing abstract thinking of students and especially girls.

The task “Visiting friends” is very hard for both boys and girls (Figure 6 (right)). In order to solve this task students need to be able to do top-down analysis and observe the periodicity from the simulation, also abstraction thinking is needed.

5 Conclusion

Competitions play an important role as a source of motivation students to learn informatics (or computer science, or computing) in a non-formal way. Our ten-year experience running the *Bebras* contest has shown that both students and teachers can gain deeper skills and understanding of informatics concepts. Well-organized informatics contests with conceptual-based, exciting, playful tasks invite students to use computer reasoning and to explore understanding of technology.

The international task workshop is organized annually for developing informatics tasks and producing a task pool, from which each country is obliged to choose tasks for their national contest. Preparation and selection of tasks are very important processes. Lithuania is using the same task set as Austria, Germany, Switzerland, The Netherlands, and almost overlapping with tasks in Finland and Sweden.

It is not easy to estimate how difficult a task will be for a particular age group when developing the task. Our analysis has shown that last year's task set was balanced well enough at least for Lithuanian students: we got a distribution of scores very close to the normal distribution (the Bell curve). A few students do very well and a few do very poorly. A bunch of scores end up clumped around the mean score.

The large and multifaceted data collected in the *Bebras* contests make it possible to analyse many interesting aspects related to e.g. students' understanding, difficulties and misconceptions based on different factors. In this paper, we have looked into tasks and assign them to cognitive skills domains according to the revised Bloom's taxonomy. We found that the *Bebras* tasks are well-balanced according the cognitive skills' domains: at the most tasks are in the high categories Understanding (15), Applying (20), Analysing (12) and Evaluating (12).

An international contest on informatics *Bebras* involves more than twenty countries, cultures and languages. Clearly, these are all factors that make it challenging to create unambiguous and clear tasks.

Acknowledgements

The authors want to explicitly thank all members of the international *Bebras* contest on informatics and computer fluency community that took part in task development and influenced in this way the outcome of this paper.

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Biographies

Valentina Dagienė is a professor at the Vilnius University Institute of Mathematics and Informatics and head of the Department of Informatics Methodology. She has published over 150 research papers and the same number of methodological works, has written more than 60 textbooks in the field of informatics and information technologies for secondary schools. She has been working in various expert groups and working groups, organizing the Olympiads in Informatics among students.

Gabriele Stupuriene is a young researcher in the Vilnius University Institute of Mathematics and Informatics at the Department of Informatics Methodology. She is involved in a National project on localisation of education software (*Mahara, Claroline*). Since 2010 she has been working on Informatics contest *Bebras* tasks. She has developed and defended her Master thesis "Conceptualisation of Informatics Fundamentals through Tasks" in 2011.

Annex

Short number	Idea from	Title	What student can learn from the task
M1[5]	Slovakia	The Necklace Machine	algorithm; programming; sequence; repeat; pattern
M2	Slovakia	Tools	understanding a tool
M3	Slovakia	Beings	logics
M4	Slovakia	Train	logics
M5+B1	Slovakia	In the Forest	finding a path; graph; tracing; finding a solution backwards
M6+B2	Hungary	Ice cream machine	detecting an algorithm; machine work; loop
M7	Lithuania	Towns	graph theory
M8+C1	Czech R.	Rotation tool	understanding a tool, what it is able to do and what not, rotate a tool, transformation
M9+B3+C2	Canada	More Candy	longest common subsequence; dynamic programming
M10+B4	Slovakia	Bee Hive	algorithm; robot navigation; follow sequence of instructions
M11+B5	Slovakia	Jeremy in the Bushes	algorithm; robot navigation; tracing
M12+B8+C3[6]	**Russia**	**Balls Trigger**	logics; trigger; logical gate
M13	Bulgaria	Follow the squirrel	turning; instructions; sequences of instructions
M14	Slovenia	Labyrinth	route planning
M15	Latvia	The making of a panoramic view picture	panorama view; puzzle
M16	Russian	Beavers in an elevator	optimization problem
M17	Slovakia	Ladybug Dotty	program; condition; tracing
M18+C4	Germany	Loading trucks	optimization
B6	Japan	Drumming	iteration; repetition; loops; following instructions
B7	Germany	Homework	e-mail etiquette
B9	Lithuania	Cities	representation of information: linking several types of information
B10	**Japan**	**Zebra Tunnel**	to follow instructions; algorithm analysis; data structures: FIFO (queue) and LIFO (stack)

5 Underline font indicates interactive task.

6 Bold font indicates *Bebras* mandatory tasks which must be included by all countries in their contests.

B11	France	Swapping	implicit, directed, graph
B12+C5	Sweden	The importance of an instruction	instruction; human machine instruction
B13+C8+J1+S1	**Japan**	**Signal Fire**	graphs; shortest path problem; breadth-first search
B14	Lithuania	Taking pictures	panorama view
B15	Sweden	Frog trouble	shortest path; breadth-first search
B16	Austria	The takeaway	memory; management of data structure; stack
B17	Belgium	Rescue action	tree traversal; recursive definition; optimisation problem
B18	Germany	Soda Machine	finite stet automata; coding
B19+C9	Slovenia	The Highest Tree	search algorithm; local optimisation; global optimum
B20+C1+J8+S2	**Slovenia**	**Spinning Toy**	binary tree representation; tree traversal; operations abstraction
B21+S8	Switzerland	Build the bridges!	minimum spanning tree, Kruskal's algorithm, Prim's algorithm, graph theory
C6	Slovenia	Gossiping	graph theory
C7+J2	**Slovenia**	**Necklace**	shortest path to reach the end
C11	Hungary	Gift boxes	algorithm; recursion; breaking the problem down into smallest problems
C12+J3	**Austria**	**Airport**	applying rules; structure; scheduling; limited resources
C13+J4	Japan	Bebras Rowing	binary number; bit; numeral system
C14+J5	Austria	Helping grandpa beaver creating his password	e-mail; security; password enforcement; applying rules
C15	Netherlands	Triangle code	encryption; decryption; description algorithm
C16	Canada	Putting people in line	Bubble-sort; sorting techniques; algorithm running time
C17+J6	France	Sort by weight	sorting algorithm
C18+J7+S3	Germany	Movie seating	graph theory; optimal; relation
C19+J9	France	Beaver the hobbit	graph; shortest paths; brute force approach
C20+J10+S4	Switzerland	Serial Transmission	RS232; serial transmission; bits; bytes
C21+J15	Switzerland	Flowchart computing	flowchart; computer program representation; visualization
J11	Japan	Storehouse	Binary search
J12	**Slovakia**	**Dice**	following a list of commands; procedure; imperative programming

J13+S5	Switzerland	Domino circles	Eulerian path; graphs; largest Eulerian subgraph; modelling graph
J14+S9	Germany	Random Pictures	computer graphics; non-determinism; programming; variables
J16	Japan	Shortest Path	division a task in smaller parts; dynamic programming
J17+S15	Netherlands	Turn the cards	logic reasoning implication
J18+S10	**Netherlands**	**River inspection**	algorithm; flow problem; planar directed graph; maximal cut; sweeping line
J19+S11	**Taiwan**	**Visiting Friends**	counting; top-down analysis; modulo operations; patterns; observing the periodicity from the simulation
J20+S12	Austria	No turning left!	graph; shortest path; algorithm; determine a path with minimum effort
J21+S13	Austria	From A to C	perform instructions; algorithm
S6	Taiwan	Delicious Dinner	job scheduling
S7	Austria	Apple in the basket	patterns; invariants
S14	Netherlands	Treasure hunt	Binary search, divide and conquer
S16	Belgium	Old computing machine	programming; assembly language; abstraction
S17	Germany	Colored Necklaces	syntax diagrams
S18	Netherlands	Hotel key	encoding; combinatorics
S19	Belgium	The magic machine	Petri net; graph; algorithm
S20	Italy	Beaver Student back home	algorithms; constraints; programming
S21	Latvia	Raid arrays	Raid array; data redundancy