The Education Column

BY

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Bringing Informatics Concepts to Children Through Solving Short Tasks

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Abstract

Throughout the world, educators have recognized that computer science or informatics fundamentals need to be introduced at all levels of schools. This can be done using various approaches. One of them is an international challenge on informatics and computational thinking named "Bebras." We are going to survey the goals of the contest and discuss some examples of Bebras tasks.

Before last Christmas, president Obama signed the bipartisan *Every Student Succeeds Act* – a long-overdue replacement of the federal education law known as *No Child Left Behind*. He put forth some specific proposals for his remaining year in office. And the very first one was "helping students learn to write computer code." He said: "In the coming years, we should build on that progress, by ... offering every student the hands-on computer science and math classes that make them job-ready on Day 1." [5]

Obama is not the only proponent of this idea. The largest public school systems in the country, New York City and Los Angeles Unified, have both announced that they are moving toward exposing all students to computer science. Coding is also newly part of national curricula in the U.K. and Australia and some countries in Europe.

Attracting youngsters to get fundamentals of computer science (i. e., informatics; an equivalent terminology often used in Europe) is a challenge for educators in many countries. It is not easy to establish informatics as a subject at all school levels in many countries. It takes time. There was an idea to bring informatics education to the students in a non-formal way, for example using contests or other outreach activities.

The idea of developing contests on informatics and computer fluency for school students was raised in Lithuania in 2004 [2]. Recently, the contest is being

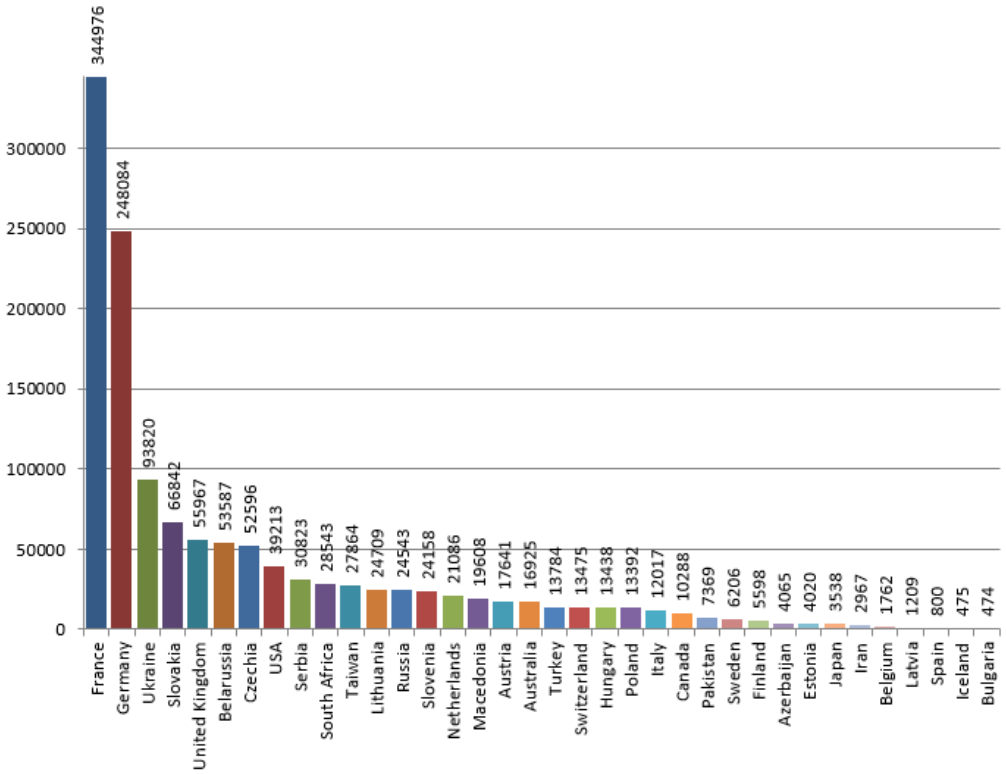


Figure 1: Number of participants in a Bebras week in November 2015: over 1.3 million school students from 36 countries in total.

spread through more than 40 countries, and expecting to reach more than 50 countries this year. In November last year, the Bebras week attracted over 1.3 million participants from 35 countries (Figure 1). Few countries from the southern hemisphere (Australia, Malaysia, New Zealand, Singapore, South Korea, also Israel and Cyprus) will run the contest in March.

The contest name "beaver" – in Lithuanian "bebras" – was chosen in connection with the hard-working, clever, goal-seeking and lively animal. The contest has been growing from a single contest (a Bebras week in November) into various informatics education activities through countries during over all year. After the ten years anniversary, the title of the contest has changed to *International Challenge on Informatics and Computational Thinking* [1].

The main goal of the Bebras challenge is to motivate pupils to be more interested in informatics topics and to promote thinking, which is algorithmic, logical, computational, and based on informatics. The Bebras project has to promote students' interest in informatics from the very beginning at school (including kindergarden as well) and to motivate students to learn and master technology [4].

Specifically, the idea was to encourage pupils to deeper understand computers and to support the development of computational thinking [6].

The Bebras challenge is organized within countries and performed at local schools at computers offering 15 to 24 short tasks to be solved within 45 to 55 minutes. There are different task sets for the age groups. Names and variety of age groups depend on the countries. Six age groups are suggested: Little Beavers (grades 3 and 4), Benjamin (grades 5 and 6), Cadet (grades 7 and 8), Junior (grades 9 and 10) and Senior (grades 11, 12, and 13). The contestants are usually supervised by teachers who may integrate the contest into their teaching activities.

The Bebras tasks essentially contribute to the development of our educational systems both for pupils and teachers. Pupils have been "pushed" to think about fundamentals of informatics, educators should think about harmonization of a syllabus of informatics. Creative and interesting tasks are the main drive for the Bebras challenge.

At the Bebras challenge, tasks are an important source for introducing children to informatics concepts and procedures. The most important goal of the Bebras challenge is to present informatics concepts in an understandable way and in an attractive format so that everybody can learn these concepts and would like to learn informatics. In the short Bebras tasks, we can involve concepts of informatics like algorithms and programs: sequential and concurrent; data structures like heaps, stacks and queues; modeling of states, control flow and data flow; human-computer interaction; graphics; etc. Using a proper problem statement, nearly all aspects of informatics can be topic of a Bebras task.

Tasks are highly valued at the Bebras challenge and their development has been used in teacher training courses and workshops. Task development workshops were used as a means to help teachers being involved in teaching informatics and to support them in reflecting on and revising what informatics is. Many teachers are involved in creating new Bebras tasks. Each of about 40 countries prepares several tasks that are submitted to the international task workshop. During the preparation of tasks for the international workshop, depending on the country, groups of teachers, university classes or local workshops are involved to create tasks. Such learning outcomes are very important for the Bebras challenge, but the things learned are also transferable to daily teaching at schools. Good tasks are the core of good teaching.

Moreover, the tasks have to be selected carefully, with regard to different aspects of each task (i. e., what educational power it has) and interpretation of its attractiveness to pupils (whether it stimulates the motivation of learning). Several task types have been developed: information comprehension; representation (symbolic, numerical, visual); coding, encryption; algorithmic thinking, including programming aspects; using computer systems, e. g., search engines, email, spread sheets, etc.; general principles, but no specific systems; structures, patterns

and arrangements, combinatorics, discrete structures (graphs, etc.); social, ethical, cultural, international, legal issues [4].

Each year, the international Bebras workshop develops a set of new tasks and questions. The group of international experts in didactics and computer science follows a process that allows creativity in finding new tasks and ensures a high quality of the output. Each Bebras task should meet the following criteria: (1) the task should have a clear informatics concept inside; (2) the task can be solved within 3 minutes; (3) the task is short, usually presentable on a single screen page including pictures; (4) the task is independent from technical details and computer programs.

Usually, informatics tasks are not solvable within 3 minutes. So the tasks for the Bebras contest have to concentrate on smaller learning items. Due to the independence from technical details, the focus of the tasks is not on computer applications but on the understanding of the principles, ideas and concepts that are the background of informatics as a science.

The Bebras challenge should motivate pupils to be interested more deeply in informatics. This goal can only be reached if the tasks are interesting and provoke engagement and excitement. Pure knowledge testing tasks are often not as exciting as tasks where computational thinking is necessary to solve them. Most of the Bebras tasks give new situations the pupils have never seen before, so thinking is the only way to find the correct solution.

Interactivity is very typical for using computers, so it is clear that a computer-oriented contest should apply interactive elements to explain or solve tasks. Very often, these interactive elements are "funny" to use and make it much easier to understand the problem statement. Especially the interactive elements need a lot of effort in the implementation of the tasks. But due to the attractiveness of interactive tasks, the high effort for implementing them is worth to be done.

Three Bebras tasks, as illustrated examples, are presented below.

Example 1. Anchestor (idea suggested by Japan)

"The Ancestor" deals with a data structure concept, in particular with the concept of a class that is very important in object-oriented programming (Figure 2). In order to find the differences between the pictures, pupils have to find out about the essential attributes of the depicted faces first. The list of attributes and their possible values is: ears (small, large); mouth (plain, smile); nose (small, large); number of teeth (2, 3); whiskers (curly, straight).

B-taro is planning an animation, which shows a sequence of pictures of a face. The animation should run smoothly. Therefore, the order of the pictures is correct, if only one attribute of the face changes from one picture to the next.

Unfortunately, the pictures were mixed up. Now B-taro must find the correct order again. Luckily, he knows which picture is last.

Drag the photos to the right place.

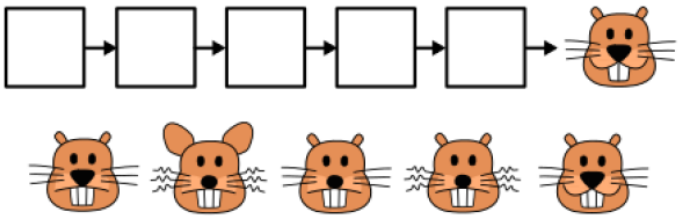
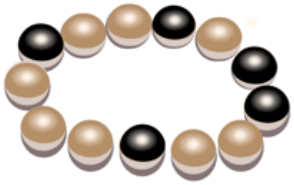


Figure 2: Ancestor – an interactive Bebras task

For the grand ball, a princess put on the bracelet with dark and light pearls shown to the right. After the ball, she unfastened the bracelet between two pearls and put it in a chest. The next evening, she wanted to put on the same bracelet but there were many similar bracelets in the chest.



Which of the following bracelets did the princess wear to the grand ball?

A.

B.

C.

D.

Figure 3: A multiple-choice Bebras task

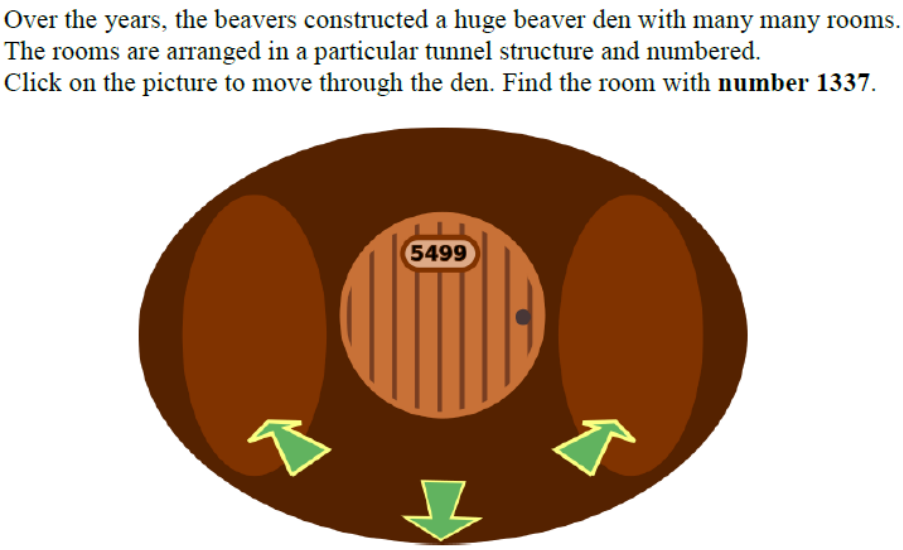


Figure 4: An interactive Bebras task

Example 2: Pearl bracelet (idea suggested by Czech Republic)

The bracelet is an example of a sequence of objects (Figure 3). The pearls are arranged in a certain pattern. When identifying the correct bracelet, you have to look for properties of this pattern. In computational thinking, it is important to be able to recognize patterns which may be useful to us. Recognizing patterns helps us to find similarities in things that may look different at first, but have something in common.

This task also deals with verifying a proposed solution: the possible answers need to be checked against the original bracelet to see if they meet the required order of the colors. The same process of verifying a solution is important in computing in order to determine if the output of a program is correct.

Example 3: Biber Hotel (idea suggested by Switzerland)

The structure of the beaver den is a binary tree, meaning that from every room (node) there are (possibly) two branches leaving to further rooms (Figure 4). The room-number (or any other ordered data) serves to navigate and find a room again. Data on a computer can also be organised in such way (like for instance names and phone numbers).

Despite having several millions of entries, an entry (or its absence) can be found in less than 25 comparisons. In fact, with at most n comparisons (the depth of the tree) it is possible to distinguish between $2^n - 1$ entries. For $n = 10$ we have

1023 possible entries, for $n = 20$ we have a little over 1 million entries, and for $n = 30$ over one billion.

More task resources and publications can be found at `http://www.bebras.org`. Moreover, many countries (Austria, Australia, Canada, Switzerland, UK, etc.) have produced Bebras brochures with solutions explanations and informatics concepts analysis, see `http://www.bebras.org/?q=documents`.

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