A Contest on Informatics and Computer Fluency Attracts School Students to Learn Basic Technology Concepts

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Abstract: Contests at school may attract students to be interested in technology. The international Bebras contest on Informatics and Computer Literacy shows that even short tasks can provide interesting problems that give insight to technology concepts. Within 45 minutes the pupils have to solve about 18 tasks of different difficulty level. There are different task sets available for different age groups from grade 5 to grade 13. A proper design of the tasks allows school students to solve tasks that involve even advanced topics of computer science. The key idea behind these tasks is not to ask for already learned facts but to give problems that allow students to learn something about concepts that are maybe new for them. We show some typical tasks which allow to learn some aspects of informatics concepts like algorithms, structures, concurrency, information representation, proper use of ICT, modeling, etc. The performance of Bebras contests in 9 countries during the last 4 years showed an unexpected and unusual 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.

Keywords: Competition, Computer Science, Computer Fluency, Primary and Secondary Education, Problem Solving

1. Background

Students especially at school age like to compete in various areas. Competitions in sports provide the most exciting examples. Competitions can also be contests or challenges, and such variations on the competition topic are more important for education. In a contest, the main interest is in the quality of the individual performance. Contestants are confronted with problems, while competitors are confronted with each other. In education, confronting students with problems is typically used to test the students' level of ability or knowledge.

Thus, setting problems is a means of setting or expressing educational standards, or make agreements on basic requirements and concepts. Furthermore,

students – gifted students in particular – can also be challenged by problems that cannot be solved by only applying learned mechanisms, but require special talent, mental abilities, and probably extraordinary effort, too.

Most computer science contests for secondary school students focus on programming or robotics, e.g. International Olympiad in Informatics (IOI Regulations, 2005; IOI home page), Robocup Junior (Robocup-Junior home page), First Lego League (First Lego League home page). It was a natural demand to have a contest on computer science for school students as it is in other subjects (e.g. Kangaroo in mathematics). Thus the idea of establishing a contest on computer science for school students was born. The contest was named BEBRAS due to the Lithuanian name of the animal "beaver" (the contest originated in Lithuania) – the International Bebras Contest on Informatics and Computer Fluency (Bebras, 2008; Dagiene, 2006, 2008). The name Bebras – in English "beaver" – is connected with the hard-working, intelligent, goal seeking and lively animal living around lakes and rives in Lithuania and other countries.

Any contest needs to have first, a challenging set of tasks and second, a grading procedure. Most important are tasks (Dagiene, 2006). For the Bebras contest it took almost a year to create tasks and to prepare technology to implement it: the first contest started in October 2004, in Lithuania only.

The Bebras contest idea's authors had the goal to extend this contest to international level. During the Baltic Olympiad (May 2005), the first international Bebras workshop for creating tasks was organized (11 countries took part). Participants have spent a lot of time discussing the structure, grading procedure, and development of the Bebras contest as well as preparation of tasks.

The International Bebras Organizing Committee was established during the second workshop in May 2006 in Lithuania (International…, 2006). The main goal of the workshops is to develop the set of tasks for the forthcoming Bebras Contest.

For contests it is important to choose the right form of organization. Nowadays many contests on computer science are organized as internet contests, like (USACO) or offer an internet contest in parallel. The Bebras contest started in a coordinated way: run of contest at schools, where solutions may be submitted to some central authority or some local organizer.

2. Success and Further Developments of the Bebras Contest

The Bebras contest's main aim is to stimulate an interest in informatics (computer science) by providing students with an opportunity to compare their abilities against the abilities of other students from different schools and countries. The contest should help to engage students of any age to take an interest in informatics and technology application (Dagiene, 2005).

Understanding and handling the basics and foundations of computer science is more important than knowing a lot of 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 oneself. A computer has to be understood at many levels, including: as a fundamental culture 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 developing tasks.

The Bebras tasks' developers are seeking to choose interesting tasks (problems) for motivating students to deal with informatics and to think deeper about technology. Also they would like to cover as many as possible informatics and computer literacy topics. In informatics, there is also the problem of syllabus. Even if there is an education standard for informatics at school in some countries, till now there is no common agreement what should be included in an integrated syllabus using information technologies. At least agreements on tasks development criteria have to be settled (Dagiene, Futschek, 2008).

Tasks are very important both for competitors (students) and task developers (teachers): students have been "pushed" to think on computer science, educators should think about harmonization of syllabus of computer science. Creative, interesting tasks are the main drive for the Bebras contests.

In the past few years, the number of the Bebras participants has been notably growing. In 2007, the Bebras contests took place in seven countries, with about 50 000 participants total. Most participants, about 22 000, came from Germany. About 40% of German participants were girls.

In 2008, more than 90 000 students from 9 countries played the game, world-wide (Bebras, 2009). Estonia had the strongest relative participation with 4 039 contestants, Germany had the highest total number of participants, exactly 53 602. Seven further countries are going to run Bebras competitions (Czech Republic, Cyprus, Egypt, Finland, Italy, Israel, and Macedonia).

3. Tasks support learning of basic concepts of Informatics

The key idea of a contest is to motivate the participants to be more interested in the corresponding topic. In our case it is Informatics, not only applications of ICT but in especially also basic concepts of Informatics.

3.1 Basic concepts of Informatics

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 educational principle (Bruner, 1960). Fundamental ideas fulfil due to (Schwill, 1997) the 4 criteria

- 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)

Andreas Schwill gave three examples of fundamental 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 4 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.

3.2 Bebras Task Types

In (Dagiene, Futschek, 2008) we presented the following 7 task types for the purpose of an easy to be understood classification of tasks within at most 7 groups. The descriptions of these task types involve also 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 contest.

INF Information comprehension
Representation (symbolic, numerical, visual)
Coding, encryption
ALG Algorithmic thinking
Including programming aspects
USE Using computer systems
e.g. search engines, email, spread sheets, etc.
General principles, but no specific systems
STRUC Structures, patterns and arrangements
Combinatorics
Discrete structures (graphs, etc.)
PUZ Puzzles
Logical puzzles
Games (mastermind, minesweeper, etc.)
SOC ICT and Society
Social, ethical, cultural, international, legal issues

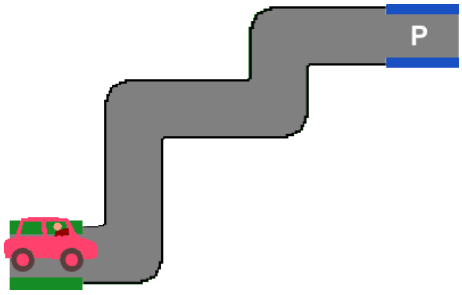
In the short Bebras tasks there we can involve concepts of informatics like algorithms and programs: sequential and concurrent; data structures like heaps, stacks and queues; modeling of states, control flow and data flow; human-

computer interaction; graphics; etc. Using a proper problem statement nearly all aspects of computer science and ICT can be topic of a Bebras task.

3.3 Examples of Tasks

3.3.1 Task "Park a Car"

A simple task that involves some aspects of algorithms and computer programs is the task "Park a Car" for the youngest participants, grade 5 to 6.



You can describe the path of the car from the given position to the parking place by the following commands:

forward – go forward to next curve or to the parking place,
left – turn left in a curve without moving forward,
right – turn right in a curve without moving forward.

Which sequence of commands properly describes the path of the car from its starting position to the parking place?

a) forward, left, forward left, forward, left, forward, right forward
b) forward, left, forward, right, forward, left, forward, left, forward
c) forward, left, forward, right, forward, left, forward, right, forward
d) left, forward, right, forward, left, forward, right, forward

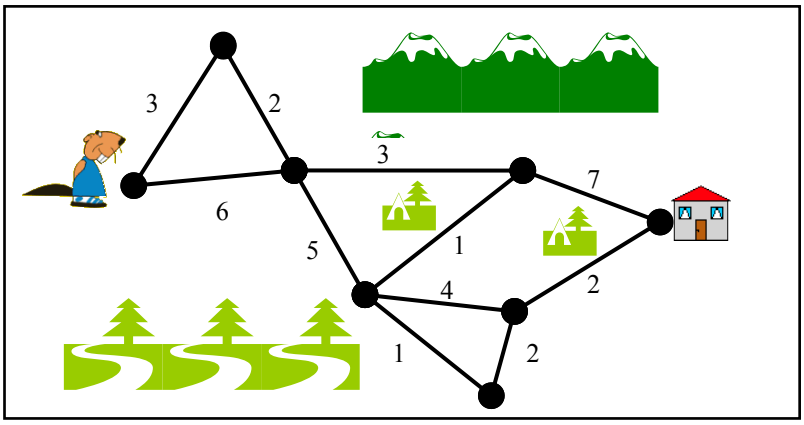
Figure 1 Task "Park a Car", Bebras Contest 2008, type ALG, easy, benjamin

This task involves the concept of describing real activities by commands of a certain language (abstraction) and the concept of sequential execution of commands. Both concepts can be understood in this example even from the youngest without prior knowledge of programming.

3.3.2 Task "Fastest Way"

The following task "Fastest Way" involves some aspects of algorithmic thinking, modeling and structures.

Beaver wants to go home as fast as possible. In the drawing you see the duration in Minutes needed to come from one point to another.
What is the shortest possible time?



a) 17 Minutes b) 14 Minutes c) 15 Minutes d) 16 Minutes

Figure 2 Task "Fastest Way", Bebras Contest 2008, type STRUCT, medium, benjamin

To solve this problem one has to work within a model of a possible real road network and develop a strategy to compare the length of all possible paths that beaver can go home. This task can also be solved from very young students without pre-knowledge of shortest paths algorithms. This task helps to develop efficient strategies of finding the shortest path.

3.3.3 Task "Beaver Creek"

The task "Beaver Creek" allows some insight in autonomous agents that act in parallel and may run in a so-called deadlock.

In Beaver Creek there are some tracks. Because Beavers don't go backwards there are some parallel tracks to give way. Look at the figures. In each cell can be only one beaver. **In which situation a total traffic jam is unavoidable?**

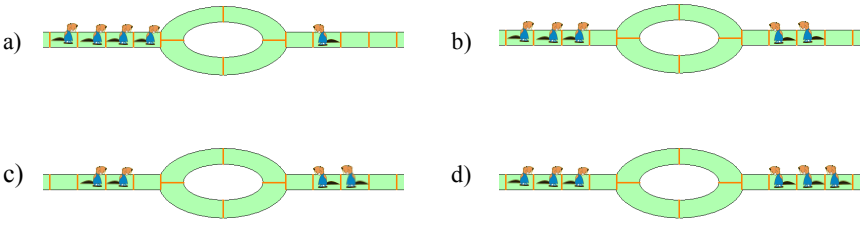


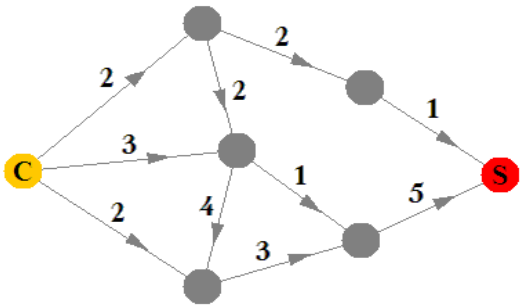
Figure 3 Task "Beaver Creek", Bebras Contest 2008, type ALG, medium, juniors

To solve this task one has to imagine how the beavers walk from one field to the next, where the beavers may do their steps one after the other or even in parallel! One can learn with this task that concurrent activities may end up in a deadlock where no further move is possible.

3.3.4 Task "Rush Hour" (Juniors hard)

The concept of flow in a network is topic of this task. It is not an easy task, the students have to develop a solution strategy. Surely the 4 answer alternatives may help to reduce the number of possible solutions.

> There is a football game taking place in a football stadium (S) within 5 hours. Cars start from the city centre (C) and want to get to the stadium. In the picture streets are marked by lines and intersections by circles. All streets leading to the stadium are one-way as marked in the schema. To pass a street from one intersection to another one takes exactly one hour. Furthermore, all the streets have the maximum number of cars that can pass through them in one hour (numbers next to the lines).



What is the maximum number of cars, which can reach the stadium within 5 hours?

a) 12 b) 30 c) 14 d) 15

Figure 4 Task "Rush Hour", Bebras Contest 2008, type STRUCT, hard, senior

To solve this problem one has to understand how many cars are in the optimal case in the different positions for each of the fife hours after start of all cars on the left side. Pre-knowledge is not required, but a high ability to imagine a more complex problem.

3.3.5 Task "Junk mail"

Proper behavior to avoid misuse of computers or computer criminality is very important nowadays and should be part of all Bebras task sets.

You receive a junk mail from xyz@emarket.com that suggests to forward the message to 10 of your friends and also write back to xyz@emarket.com, promising to receive $100 for such actions. **What is the correct way of action?**

a) You forward the message to your friends (writing 10 addresses separated by comma in the To: field) and write to xyzabc@emarket.com that you want your $100.
b) You forward the message to your friends (writing 10 separate e-mails) and write to xyzabc@emarket.com that you want your $100.
c) You do not forward the message to your friends and write to xyzabc@emarket.com, asking not to send spam to you in the future.
d) You update your spam filter (if you have any) to recognize such letters as spam and remove the e-mail.

Figure 5 Task "Junk Mail", Bebras Contest 2008, type SOC, all age groups

Very often this type of tasks is suitable for all age groups. Even the youngest need skills in proper use of internet and e-mailing to prevent harm and unnecessary costs.

4. Good tasks support understanding rather than learning by heart

In (Dagiene, Futschek, 2008) we described a series of criteria for creating good tasks for Bebras-like competitions. In this list it was missing that we intent to support deeper understanding rather than reproduction of previously learned facts.

The Bebras tasks presented above should be solvable within only a few minutes. Nevertheless it is possible to solve them without detailed prior knowledge of the underlying technical principles. In contrary it is possible to learn a lot about these principles by solving the tasks. Solving such problems leads to a deeper understanding of technical concepts in a fast and easy way.

A good technique to produce easy understandable tasks of a rather difficult stuff is to provide a good story (in a every day language) that tells the problem to be solved, see the presented tasks "Rush Hour" and "Beaver Creek". In (Dagiene, Futschek, 2008) you can find a detailed description of a task development that deals with a problem connected to the heap data structure. Due to a good story in the final problem statement of this "group photo task" the students need neither pre-knowledge of the heap data structure nor a definition of the heap data structure within the problem statement of the task.

All Bebras tasks posed at 2008 Bebras contest in Germany (Informatik-Biber) and Austria (Biber der Informatik) do not rely on already learned facts. Problem solving skills that are somehow typical for informatics must be applied to solve them. Thinking is necessary to solve good tasks, thinking is a prerequisite for understanding a concept and therefore the essence of learning.

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