

# Task Types at “Beaver” Contests

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**Abstract.** Education process is connected with computers in different ways. Therefore, it is necessary to find proper place for computers in this process. One way to attract young people is using computer-based competitions. There are well-known programming competitions (Olympiads in Informatics) where deep knowledge of programming and algorithms is necessary. However, only a small part of students is involved in these competitions. During the last years, an information technology competition for all students from age 10 to 19 was developed and implemented in some countries. The name “Beaver” is connected with the hard-working, intelligent, goal seeking and lively animal. Creation of interesting tasks is one of the most important issues of the competition. This paper deals with criteria for developing as well as selection of tasks for the “Beaver” competition.

**Keywords:** information and communication technology, problem solving, computer science, competition, learning by doing

## 1 Introduction

If we observe existing computer competitions for students, we will see quite different ones. On the one hand there are pure computer game tournaments, attracting young people as well as mass media [18]. On the other hand there are competitions with serious scientific content like International Olympiad in Informatics [9] as well as National Olympiads in many countries, e. g. Estonia [8], Latvia [14], Lithuania [5, 15]. Both kinds of competitions need hard everyday work in different directions. Like in any other profession, number of participants in these top events is relatively small compared to total number of computer users at the same age group. It is quite clear that there is place for different competitions “in the middle of spectrum”. In general, these should be competitions focused not only on algorithms as Olympiads and at the same time with “non-zero” educational content. Competitions play an important role as a source of inspiration and innovation. Children are attracted by competitions, they get easier involved in such kind of activity, more willingly discuss and become more active [4, 16]. One possible form of such competitions might be a contest like “Beaver” [2].

## 2 History of "Beaver" Contest

The idea of information technology (IT) contest “Beaver” originated in Lithuania in 2003 (in Lithuanian BEBRAS). It took almost a year to implement it: the first contest started in October 2004 in Lithuania. About 3,500 students from 150 comprehensive schools were involved in it.

The main principles of the “Beaver” are borrowed from the mathematical contest “Kangaroo” [13], which is very popular in Europe (more than 3 million participants in 2006 [12]). For example, about 60,000 students participate annually in the Lithuanian tournament, covering more than 2/3 of all schools in the country.

IT competitions may be the key to the potential of new knowledge and an attractive way to bind technology and education. We understand that if “Beaver” remains a local contest, its perspectives will be rather poor. That’s why a workshop of participants from several countries was held and building of a framework of the international “Beaver” competition was started. In 2006, the International “Beaver” organizing Committee was established [11].

The main aim of “Beaver” is to promote interest in IT and informatics for all school students. The competition should help to engage children to take an interest in computers and IT application from the very beginning at school.

The IT competition should encourage children to use modern technologies in their learning activities more intensively and creatively. It should bring all school students together and encourage them to brainstorm and share their experiences.

As IT becomes a commonly used tool of education, this playful contest could ensure that boys and girls equally benefit from it. We hope that „Beaver” encourages students to learn the skills that will be needed in the labour market of the future.

Cognitive, social, cultural and cross-cultural aspects are very important while using technology – the competition will put strong emphasis on culture and language.

The competition is designed for all school students. The first “Beaver” contest was developed for three different groups according to the age structure of Lithuanian school: 11-14 years (5-8 classes), 15-16 years (9-10 classes), and 17-18 years (11-12 classes).

To spread the idea, in 2005 a workshop was organized as a satellite event for 11th Baltic Olympiad in Informatics in Panevezys, Lithuania. In 2006 the international “Beaver” workshop was held in Balsiai (Pasvalys region, Lithuania) and representatives from seven countries (Austria, Estonia, Germany, Latvia, Lithuania, The Netherlands, and Poland) participated in this event.

During the workshop the International Beaver Committee (IBC) was instituted.

### **3 Types of Tasks**

Existing format of competition puts quite strong limits on task format. Average time for solving one task is 2-3 minutes, so task descriptions must be short in form. Automatic grading system as a rule requires precisely defined correct answer (or a unique set of them). As a tradition, four possible answers are given. Our opinion is that together with the option to combine these answers in sets, allowing more than one correct answer, the possibility of successful guessing is minimized. Interactive tasks which were also present at first two “Beaver” competitions are very attractive, but their preparation is significantly more time consuming and technically challenging than the classical ones, so their further usage is still under consideration.

Short form of task descriptions puts limits on suitable topics and task types. If student is completely unfamiliar with some topic, it is nearly impossible to give satisfactory introduction to explain basics at a level sufficient for understanding and correctly answering any non-trivial questions. As an example, we would like to mention elements of LOGO, where in very compressed form basics are explained in such a manner that this knowledge is quite enough for successful solving of the problem even for people who till reading this particular task description were not familiar with LOGO. An example of such a task is given in section 3.5.

Besides the restrictions imposed by the competition format, there is also the problem of syllabus. Even if there is an education standard for Informatics at school, there till now is no common agreement on what should be included in a syllabus for IT competitions. Even for the International Olympiad in Informatics (IOI), the preparation of a syllabus is still an ongoing process [17], and the most optimistic plan is to finish with some document at the beginning of 2007. We might use some guidelines from e. g. the UNESCO recommendations [10] or the ECDL programme [6].

As a consequence, there is no well-defined syllabus for lower level Olympiads in Informatics – national or regional. At the first look, this may seem strange – how is it possible to participate in a competition without preliminary knowledge about the essence of tasks? However, tradition combined with a stable group of task creators, with their understanding about optimal coverage of topics, is a base on which other participants (students, teachers) may build their expectations about task content even without a proper syllabus. Of course, after some time, you can notice that tasks prepared by small group of specialists become similar to one another. Such a situation rises due to several factors. Every author has his own preferences, favourite topics, expressing style, etc. On the other hand, it is not so easy to find fresh topics year after year without repetitions.

“Beaver” workshops were chosen as a way to overcome the potential danger of narrow-focused and self-closed task themes as well as a way to promote the idea of the contest to other countries. Influence of the first (2005) workshop is very well visible when comparing “Beaver” task sets from the two competitions (Beaver'2004 and Beaver'2005).

At the second workshop (2006), a brainstorming session was held to generate ideas for different types of questions and tasks that could be used in the competition. More than 120 tasks were created, from which about 90 were accepted for further elaboration. The proposed topics could be divided into the following major groups:

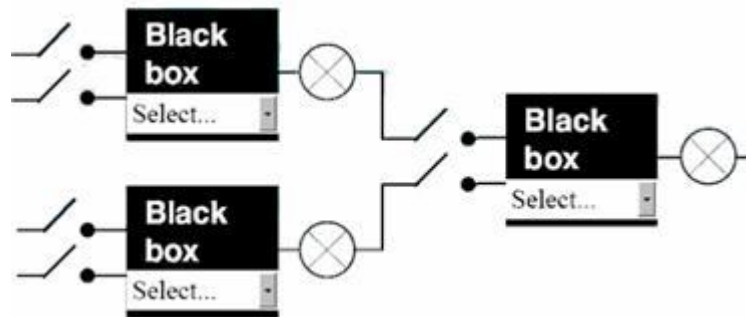
1. General logic
2. ICT in everyday life
3. Practical and technical issues
4. Information comprehension
5. Algorithms and programming
6. Mathematics underlying CS
7. History and trivia

### ***3.1 General Logic***

The tasks under this topic should be based on general logic and reasoning, such as the laws of cause and effect. Even if these issues are not specific to Information Technology (IT) or Computer Science (CS), the ability to reason clearly and logically is useful in any branch of science and this obviously includes computer science.

In particular, the tasks could be based on well-known desktop games, simple logic games made up for the contest, general puzzles, etc. Due to the international setting and task format, caution must be exercised in assuming the contestants' advance knowledge of the rules of any specific games.

As a special case more connected to CS, also tasks based on propositional calculus and perhaps even predicate logic (though the latter probably using natural language instead of the standard mathematical formalisms) could be given. In particular, the logic gates underlying the binary computers could be introduced to the students by tasks under this topic (again, the behaviour of the gates should be defined, as this is generally not covered in the classroom). Fig. 1 shows an example of a task of this type.



**Fig. 1.** Interactive general logic task: “Each black box may contain one of two devices: either conjunctive or disjunctive one. By switching the switches in the network, determine which of them is in each box. Select the proper device from the drop-down list.”

### 3.2 ICT in Everyday Life

This topic includes tasks related to the practices and implications of using ICT in everyday life. Aspects as varied as economics behind ICT or applications of various gadgets, such as cell phones, could be used as the basis of the tasks. It could be useful to include also tasks on applying computers to solving problems in other subjects, such as physics, mathematics, etc.

The tasks could also be based on social and ethical issues arising in connection with ICT, such as copyright and netiquette, or perhaps even implications of heavy computer usage on one’s health.

These tasks could perhaps also be used to introduce the topic of cultural diversity into the classroom. After all, it is the modern communication technologies that have made the world a rather small place and are likely to cause people from different cultural backgrounds to come in touch with one another.

An example of this type is the following task:

*“Browsing the Internet, you have found a fancy image with the following remark: **All rights protected by the copyright laws.** Which of the following would be the most proper decision if you wish to publish the image on your own website?*

- A. *You must ask for the permission of the organization that holds the copyright of the image.*
- B. *All information published in the Internet is public; therefore you can copy and use the image without any problems.*
- C. *You can use this image as you wish since there is no copyright sign © on the page.*
- D. *You should only mention the source URL when such images are used.”*

### 3.3 Practical and Technical Issues

The practical “nuisances” of using ICT, such as file formats, encodings, etc, could also be a source of interesting tasks. Of course, it would be better to base the tasks on more general knowledge (such as the difference between vector and raster graphics, or a text document and an image of that text) than very specific and potentially quickly changing facts (such as whether one spreadsheet program is or is not able to read the file format of another one, which can change from version to version).

Problems based on knowledge of standard functions of general software, such as text editors, word processors, spreadsheets, etc, could be posed under this topic. Questions about various network protocols could also be considered, as well as knowledge related to standard hardware.

Computer security is also a practical concern, mainly arising from technical specificities, thus questions related to data protection and safety (such as backups, passwords, etc) could be very well considered within this group.

Perhaps it is also possible to introduce the more technical aspects of cultural diversity (such as internationalization and localization issues: differences in alphabets and sorting, number and date formats, writing order, etc) by tasks under this topic.

An example is the encoding task shown on Fig. 2.

Select the appropriate encoding for each fragment of Lithuanian newspaper.

Trečiasias pergales iš eilės Baltijos vyrų krepšinio lygos (SEB BBL) reguliariojo sezono rungtynėse iškovojo septyniolikos komandų turnyro favoritai - Kauno "Žalgiris" ir Vilniaus "Lietuvos rytas", kurie iki minimumo sumažino atsilikimą iki turnyre pirmaujančių "Šiaulių" (4 pergalės) krepšininkų.	Trečiasias pergales i eilės Baltijos vyrų krepšinio lygos (SEB BBL) reguliariojo sezono rungtynėse iškovojo septyniolikos komandų turnyro favoritai - Kauno "žalgiris" ir Vilniaus "Lietuvos rytas", kurie iki minimumo sumažino atsilikimą iki turnyre pirmaujančių "šiaulių" (4 pergalės) krepšininkų.
Select...	Select...
Trečiasias pergales iš eilės Baltijos vyrų krepšinio lygos (SEB BBL) reguliariojo sezono rungtynėse iškovojo septyniolikos komandų turnyro favoritai - Kauno "Žalgiris" ir Vilniaus "Lietuvos rytas", kurie iki minimumo sumažino atsilikimą iki turnyre pirmaujančių "Piaulim" (4 pergalės) krepšininkų.	Trečiasias pergales iš eilės Baltijos vyrų krepšinio lygos (SEB BBL) reguliariojo sezono rungtynėse iškovojo septyniolikos komandų turnyro favoritai - Kauno "žalgiris" ir Vilniaus "Lietuvos rytas", kurie iki minimumo sumažino atsilikimą iki turnyre pirmaujančių "Piaulim" (4 pergalės) krepšininkų.
Select...	Select...

Fig. 2. Encoding selection task: which encoding would cause a normal Lithuanian text originally given in Lithuania’s standard code page (ISO Latin-7) to be displayed as shown in each image?

### 3.4 Information Comprehension

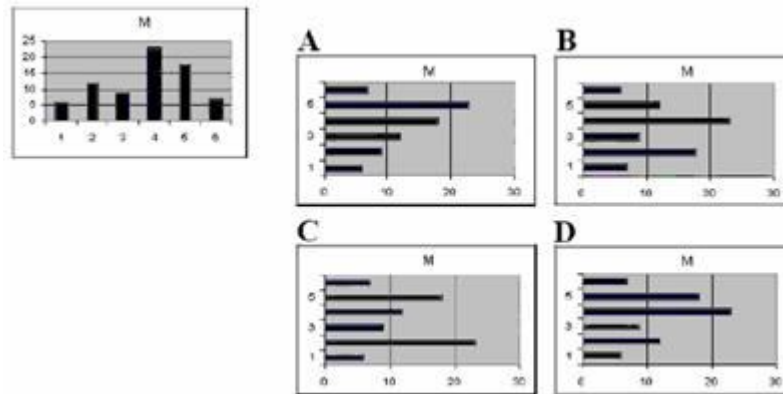
An important aspect of any kind of information handling is the ability to comprehend the meaning of the information (as opposed to merely mechanically processing it). This is increasingly a problem in the modern culture promoting form-over-substance approach through the popular media and shortening the attention spans in the younger generation.

The problems posed under this topic could be based on all sorts of data systematization and object categorization issues, but perhaps also related to searching for information (especially on the Internet, but not necessarily restricted to Internet only), assessing the relevance or reliability of any particular data items, etc.

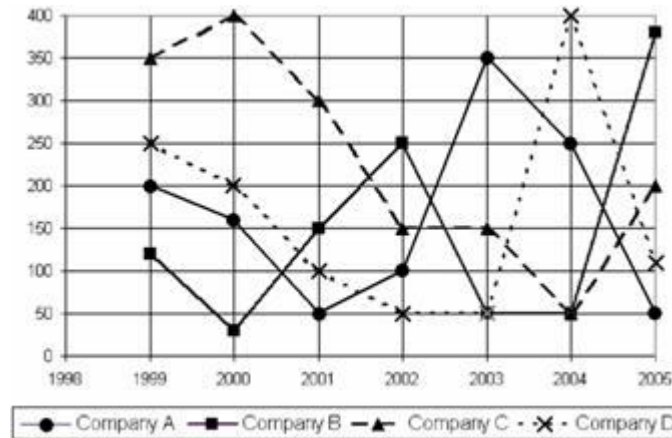
A related area is modelling, which in a competition setting probably has to take the form of interpreting a model and answering questions about the modelled system by interpreting the model. For connection to the standard IT practices, the models could be given in the form of flowcharts or

finite automata. It could probably be assumed that a flowchart is self-explanatory, at least for the older students, but other formalisms should be explained, as those are usually not covered in class.

Example tasks are given on Fig. 3 and Fig. 4.



**Fig. 3.** Information comprehension task: “Which of the given bar charts represents the same information as the column chart given on the left?”



**Fig. 4.** Information comprehension task: “The diagram shows the yearly incomes of four companies. Which one of them had the biggest total earnings over the period 2001-2005?”

### 3.5 Algorithms and Programming

It is quite impossible to discuss IT and CS without mentioning the subject of algorithms and programming. A wide variety of task types could be proposed under this general heading: defining and analyzing algorithms, implementing them in a sufficiently simple formalism (LOGO, Pascal, or a Pascal-like pseudo-language), and perhaps even topics related to debugging and testing could be considered.

Additionally, computer programming is an attractive and modern way to develop problem-solving skills [1]. Programming is an activity made up of many components: comprehension of the problem, encoding the solution, debugging, and verification. Since many of the skills required for successful programming are similar to those required for effective problem solving, computer programming and particularly choosing one of several possible solutions and later debugging in a short period of time provides a fertile field for developing and practicing problem solving skills in an environment that is engaging for young students [3].

As a special case for defining and analyzing algorithms, the DO-IT game [7] was mentioned at the “Beaver” workshop. Also, geometrical constructions using primitives and operations generally found in computer graphics packages could be used to call for constructive algorithmic thinking. The notion of analysis of algorithms could be introduced using either formalism, by asking for the minimum or maximum number of operations that might be needed to achieve a desired goal.

Another way of introducing algorithmic thinking without turning to “real” programming languages could be posing tasks in terms of search-replace in texts (which is even known to be Turing-complete under certain assumptions), simple encryption schemes, or pattern matching with regular expressions.

An example task:

“Logo Turtle may perform the following commands:

`forward n` – to move forward drawing a line of  $n$  steps long;

`left  $\alpha$`  – to turn left making an angle of  $\alpha$  degrees;

`repeat k [forward 30 left 30]` – to move forward drawing a line of 30 steps long and to turn left making an angle of 30 degrees; these actions are repeated  $k$  times.

*The turtle* looks up at the beginning.

The command

`repeat ... [forward 30 left 30]`

draws the polygonal line shown on Fig.5.

Which number should replace the suspension points?

- A. 7
- B. 8
- C. 5
- D. 6”



**Fig. 5.**

Another example (knowledge of Pascal basics is assumed): Which procedure will have the output 012345, if we will make a call to `Change (5)` ?

- A

```
procedure Change(n : integer);
begin
  Write(n);
  if n > 0 then Change(n-1);
end;
```

- B

```
procedure Change(n : integer);
begin
  if n > 0 then Change(n-1);
  Write(n);
end;
```

- C

```
procedure Change(n : integer);
begin
  if n > 0 then Change(n-1)
  else Write(n);
end;
```

- D

```
procedure Change(n : integer);
begin
  Write(n);
  if n > 0 then Change(n-1)
  else WriteLn;
  Write(n);
end;
```

### ***3.6 Mathematics Underlying Computer Science***

Some tasks should also be related to the branches of mathematics most closely related to computer science, of which logic was already mentioned before, and combinatorics could prove quite fruitful as well. Example of combinatorics task is given in the Fig.6.

On the more basic side, combinatorial tasks could be used to introduce systematic enumeration (leading up to algorithmic thinking in general), pruning search trees (leading to complexity and optimization of algorithms), and so on.

On the other hand, tasks based on many fundamental graph problems could be posed informally in the contest and used later to introduce the more formal and general treatment in the classroom.



A	B	C							
AAA	ABA	ACA	BAA	BBA	BCA				
AAB	ABB	ACB	BAB	BBB	BCB	CAB			
AAC	ABC	ACC	BAC	BBC	BCC	CAC	CBC		

**Fig. 6.** An interactive combinatorial task: “Compose all possible triplets of the three letters A, B, and C. In the given window the majority of them are already written. Add all different missing triplets. First click the chosen letter and then click the proper cell.”

### 3.7 *History and Trivia*

Even though Beaver aims to be oriented on IT skills on the practical side and to draw students to the science of computing on the theoretical side, a moderate amount of questions could be based on history of ICT and related trivia.

One potential source of trivia-type questions is terminology. To prevent these from becoming too dull, they could be based on technical terms originating in slang or proposing humorous explanations in addition to the serious ones for “define the term” or “expand the acronym” tasks.

An example task:

*"Which of the following was discovered in 1992?"*

- A. *The very first computer*
- B. *Internet*
- C. *Virus "Michelangelo"*
- D. *The very first virus"*

## 4 *Conclusions: Invitation to Join*

Despite growing number of participating countries, we are sure that this is not the limit and the “Kangaroo” contest clearly illustrates it. If “Beaver” will be positioned as a closed contest of just some countries, its perspectives will be rather poor. Therefore, International “Beaver” Organizing Committee invites everyone interested in this initiative to think about our idea, to investigate the local situation and to contact International Beaver Committee.

We are open for all kinds of proposals and ideas of collaboration and hope to find friends and partners in all countries. Integration of IT into teaching process should be our target, and we have to try to reach it together.

We are ready to share our experience, technology, and future plans with all who are interested. We expect that it will either foster your own competitions similar to the “Beaver” or will encourage you to join us. We are sure that a well-organized competition with interesting, playful, exciting problems, and attractive awards will invite children of all countries to use IT reasoning and to explore understanding of realities, possibilities, and failings of IT.

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